HURRICANE SURVEY

INTERIM REPORT

NEW BEDFORD - FAIRHAVEN

MASSACHUSETTS

APPENDICES

NOT FOR PUBLIC RELEASE

Corps of Engineers, U.S. Army - Office of the Division Engineer

New England Division - Boston, Mass.

8 FEBRUARY 1957

APPENDIX F - LETTERS OF COMMENT

rev.

APPENDIX F - LETTERS OF COMMENT

The Commonwealth of Massachusetts
Executive Department
State House, Boston

Foster Furcolo
Governor

April 11, 1957

Brigadier General Robert J. Fleming, Jr.
United States Corps of Engineers
United States Army
Office of the Division Engineer
New England Division
150 Causeway Street
Boston 14, Massachusetts

Re: NEDGW

Dear General Fleming:

This is in response to your letter of January 26, 1957 in which you state that your completed report on the hurricane survey in the New Bedford - Fairhaven harbor area was to be submitted with a recommendation that hurricane protection plan "F" would be most feasible.

I understand that the total estimated cost of this project is $17,200,000 and that $1,560,000 toward such cost would be contributed by the city of New Bedford and that there is no contemplated contribution by the Commonwealth.

I wish to assure you that Mayor Lawler of New Bedford has discussed this matter with me personally and I am in agreement with him that the proposed project would be extremely desirable for the future savings of lives and property in the area of New Bedford and Fairhaven which is peculiarly exposed to hurricane damage.

Please be assured that the Office of the Governor in behalf of the Commonwealth, extends complete endorsement to the New Bedford - Fairhaven hurricane protection project.

Sincerely yours,

Foster Furcolo

FOSTER FURCOLO

CITY OF NEW BEDFORD
MASSACHUSETTS

OFFICE OF THE MAYOR

FRANCIS J. LAWLER
MAYOR

February 19, 1957

Brigadier General Robert J. Fleming, Jr.
Corps of Engineers, U. S. Army
Office of the Division Engineer
New England Division
150 Causeway Street
Boston 14, Massachusetts

Re: File No. NEDGW

Dear General Fleming:

This is in response to your letter of January 26, 1957 in which you state that your completed report on the hurricane survey in the New Bedford-Fairhaven Harbor area was to be submitted with a recommendation that hurricane protection Plan "F" would be most feasible.

I have studied and analyzed the five items listed by you as the necessary degree of participation by local interests including land and easements, a "save-harmless" clause, relocation of power cables, operation of land features, and contribution either on an initial cost basis of $1,560,000.00 or, in the alternative, an annual operating cost of approximately $55,000.00.

Please be advised that it will be necessary to give further thought and consideration to which of the alternative methods of cost participation should be adopted; but in any event, I wish to assure you of both the willingness and ability of local interests to meet the conditions of cooperation which you recommend.

Please assure the Chief of Engineers of the complete willingness of the City of New Bedford to cooperate fully in this most desirable and necessary project.

Sincerely yours,

Francis J. Lawler

Francis J. Lawler
Mayor of New Bedford.

TOWN OF FAIRHAVEN
MASSACHUSETTS

OFFICE OF THE SELECTMEN

MEETINGS OF SELECTMEN AND BOARD OF PUBLIC WELFARE EVERY MONDAY EVENING AT 7:00

ALBERT E. STANTON, Chairman
CHARLES W. KNOWLTON
WALTER SILVEIRA

February 6, 1957

Brigadier General Robert J. Fleming, Jr.
Division Engineer, U. S. Army
150 Causeway Street
Boston 14, Massachusetts

Dear Sir:-

Reference is made to your letter of January 26, 1957 relative to your report on the hurricane survey in this area.

We have discussed this report with Mayor Lawler of New Bedford and are more or less in agreement in our views. We realize that it will be some years before any action would be commenced. We, as a Board, have no legal right to bind the Town but we believe the townspeople might go along with the recommendations as set forth in the report.

Yours very truly,

Albert E. Stanton
Chairman

HURRICANE SURVEY

INTERIM REPORT

NEW BEDFORD - FAIRHAVEN

MASSACHUSETTS

APPENDICES

Corps of Engineers, U.S. Army - Office of the Division Engineer

New England Division - Boston, Mass.

8 FEBRUARY 1957

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GLOSSARY

HURRICANE SURGE: the mass of water causing an increase in elevation of the water surface above predicted astronomical tide at the time of a hurricane; it includes wind set-up; sometimes the maximum increase in elevation is referred to as the surge.

HURRICANE TIDE: the rise and fall of the water surface during a hurricane, exclusive of wave action.

KNOT: a velocity equal to one nautical mile (6080.2 ft.) per hour (about 1.15 statute miles per hour).

OVERTOPPING: that portion of the wave runup which goes over the top of a protective structure.

PONDING: the storage of water behind a dike or wall from local runoff and/or overtopping by waves.

POOL BUILDUP: the increase in elevation of water surface behind a structure due to runoff and/or overtopping by waves.

RUNUP: the rush of water up the face of a structure on the breaking of a wave. The height of runup is measured from the still-water level.

SIGNIFICANT WAVE: a statistical term denoting waves with the average height and period of the one-third highest waves of a given wave train.

SPRING TIDE: a tide that occurs at or near the time of new and full moon and which rises highest and falls lowest from the mean level.

STILL WATER LEVEL: the elevation of the water surface if all wave action were to cease.

STORM SURGE: same as "hurricane surge."

WAVE HEIGHT: the vertical distance between the crest and preceding trough.

WAVE TRAIN: a series of waves from the same direction.

WIND SET-UP: the vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water.

APPENDIX A

GEOLOGY

APPENDIX A

GEOLOGY

PHYSIOGRAPHY

A-1. New Bedford-Fairhaven Harbor lies on the seaboard lowland of the New England physiographic province, at the confluence of the Acushnet River and Buzzards Bay, in southern Massachusetts. The area is of moderately low relief, with a maximum elevation of 183 feet above sea level. Elevations in the relatively low-lying southern parts of New Bedford and Fairhaven range from zero to 50 feet above mean sea level. Both shores are heavily populated, with important manufacturing and fishing industries and attendant docking and railroad facilities.

The harbor and surrounding land area are founded on a single rock formation, the Dedham Granodiorite, composed of a variety of igneous rock types in close and complex association with each other, and further complicated by inclusions of ancient metamorphic rocks, into which the formation was intruded. The principal soils are glacial sands and gravels, overlain in part by alluvial materials, generally redeposited glacial sediments, and in the case of the harbor, an accumulation of harbor mud. Principal mineral resources are sand and gravel, concrete aggregates, and crushed stone.

SUBSURFACE INVESTIGATIONS

A-2. Subsurface investigations, made by the New England Division, Corps of Engineers, during 1955 and 1956, in conjunction with this survey, consisted of 49 drive-sample and 8 auger borings. Some supplemental information was available in the form of probings obtained in connection with prior river and harbor investigations, foundation explorations for military facilities at Clark Point, and probings for the New Bedford-Fairhaven Bridge, the Coggeshall Street Bridge, and a gas line across the river near the New Bedford-Fairhaven Bridge.

The 1955-1956 explorations consisted of 18 drive-sample and 8 auger borings on land and 21 drive-sample borings in the harbor to determine foundation conditions along various alignments for Plan "F." In addition, 10 drive-sample borings (9 in water and 1 on land) were driven at considered upstream sites between the Coggeshall Street and the New Bedford-Fairhaven Bridges.

Subsurface explorations were supplemented with general field reconnaissance to determine surficial controlling features and the general availability of borrow. Locations and graphic logs for all explorations are shown on Plates A-1 through A-4.

FOUNDATION CONDITIONS IN THE HARBOR

A-3. OVERBURDEN

Two alignments, bored across the harbor in the vicinity of Palmer Island (see Plates A-1 and A-2), indicate zero to 10 feet of glacial till on bedrock, occurring in the depressions of the rock surface and on the landward slopes of the harbor bottom. An accumulation of about 10 feet of silty gravels and sands, and gravelly silty sands occurs, with few exceptions, wherever the till is lacking and may be in part residual from washed till, but more likely, it represents the coarser products of outwash deposition lain while melt-water velocities were still high. Silts and sands occurring in a pre-glacial depression east of Palmer Island, along the alignment of Plan "F," are fine granular and particularly high in quartz, taking on the appearance largely of rock flour, indicating a period of quiet deposition. These deposits reach a maximum thickness of about 40 feet along the alignment and are overlain by another approximately 15 feet of mostly post-glacial silts and sands, organic in part. The most recent deposits, organic silts and sands, some with shells, form a relatively thin veneer from two to three feet thick.

The present dredged channel cuts through the more recent silts and sands and into the upper part of the outwash deposits. A thin silty gravelly sand deposit, two to three feet thick, exists at the bottom of the channel and probably represents the bed of a late glacial stream on the outwash. This stream appears to have sloughed off to the west and eroded through or around the gravelly material and down to firmer materials, and the resultant depression has been filled with present day silts and sands. Rock is shallower west of the channel; consequently, most of the sediments are the coarser deposits characteristic of the earlier glacial materials. The crossing west of Palmer Island is shallow throughout, with a high rock surface, exhibiting a few feet of the coarser, firmer, earlier glacial materials overlain by less than 10 feet of more recent marine sediments. East of Palmer Island, the western half of the proposed alignment exhibits firm materials at shallow depth (less than 10 feet), while the eastern half, laden with silts, possesses slight compactness.

A-4. ROCK

Bedrock east of Palmer Island at the proposed location of the gate structure is at elevations of from minus 50 to 60 feet msl. It is weathered, gneissic, schistose in part, and fractured.

Farther east, a pre-glacial valley is indicated by a trough extending almost to the elevation of minus 70 feet. The rock surface rises west of the ship channel to outcrop on Palmer Island. Rock is shallower west of Palmer Island and appears to present a gently undulating surface, occurring between elevations of from minus 20 to 30 feet msl. More borings, however, will be necessary to establish definitely the regularity of this surface.

Borings at upstream sites indicate a somewhat more granitic rock with secondary alteration appearing at a schist contact zone. The schist is considered a probable inclusion of the pre-Cambrian complex into which the Dedham formation was intruded.

Explorations upstream and downstream in the vicinity of the proposed gate structure indicate a generally favorable degree of uniformity and considerable assurance of a platform on which to place foundations.

FOUNDATION CONDITIONS FOR LAND DIKES

A-5. Land dike explorations were shallow, averaging 15 feet, with only two reaching an elevation of minus 10 feet. They indicated satisfactory conditions with the exception of an unsuitable section of fill in the Clark Cove area, which will have to be removed and replaced at the time of construction. The dike areas west of the harbor represent tidal flats built up with sands and gravels to an elevation of about 8 feet msl. Materials encountered beneath the fill are predominantly sands which possess good to excellent compaction. Till or till-like materials encountered near the bottoms of several of the borings indicate that still firmer materials form a reinforcing basement, more than adequate for the construction of the dikes under consideration. Dike foundations east of the harbor are along an old railroad embankment on sands and gravels, which afford a firm foundation and should present no difficulties. The exploration farthest east produced decomposed rock above shallow refusal, probably representing bedrock close at hand.

AVAILABILITY OF CONSTRUCTION MATERIALS

A-6. DREDGED MATERIAL

Much of the material dredged for the bypass channel will be stockpiled on the New Bedford shore for later use as fill in the dikes. Although the suitability of this sedimentary material as fill for the main barrier has not been determined as yet, it is

expected that about three-quarters of the total earth fill required for the project will be provided by this dredged material.

A-7. PERVIOUS BORROW

Pervious borrow is readily available in sufficient quantities west and north of the harbor, well within a 10-mile haul. Development of borrow pits west of the city, near the shore, is limited because of thin mantle and a high water table; however, commercial sources are located in the town of Dartmouth, about five miles to the west, and numerous undeveloped sources lie in that general area.

A-8. IMPERVIOUS BORROW

There is a general lack of impervious borrow in the New Bedford area; however, random impervious is available, usually in the form of ground moraine or till-like materials associated with the outwash referred to as pervious sources. In several instances, development of sand and gravel pits has been curtailed owing to the presence of morainic materials.

A-9. ROCK BORROW

The nature of the underlying rock throughout the area is such that almost any exposure suitable for quarrying would provide good revetment. The major drawback to quarrying, however, lies in the shortage of extensive outcroppings, particularly those of high relief. Only one exposure is regarded as suitable from a quarrying standpoint. It is located about one-half mile north of East Freetown, (11 miles north of Palmer Island). It is doubtful whether prices competitive with commercial quarries can be obtained. The rock is a granite porphyry and appears highly suitable for revetment.

The only quarry in the immediate vicinity, Bluestone Quarry, produces a well-indurated quartzitic granite gneiss, referred to locally as trap rock. It appears conjectural, however, whether this quarry can compete with the larger coastal quarries of Connecticut and southwestern Rhode Island which produce, respectively, true trap rock and granite in large quantities and of any dimension. Transportation rates against production costs seem to balance out all sources fairly well.

A-10. CONCRETE AGGREGATES

A large source of concrete aggregates processed from natural sands and gravels exists six miles west of Palmer Island. Another nearby aggregate source is the Bluestone Quarry in Acushnet, $3\frac{1}{2}$ miles north of Palmer Island. The aggregates from this quarry have been tested and approved for construction of military projects.

The materials consist of quartzitic gneiss and gneissic gabbro. Part of the quarry contained chloritic schist along the contact zone of the two rock types, but the rock in general is fine-grained, hard and fresh. Other commercial sources exist outside a 20-mile haul radius, predominantly in the Middleborough area to the north.

CONCLUSIONS AND RECOMMENDATIONS

A-11. Conditions are highly favorable for founding the barrier gate, the major structure in Plan "F," on a sloping platform of bedrock of a type which generally possesses great bearing strength. The rock is somewhat schistose to the north and will have to be investigated in more detail by borings prior to construction in order to elaborate its lithological character, state of fracture, and local surface irregularities. The last factor is quite important since the rock section in profile resembles a serpent's back and may possess finer inundations in closer detail, possibly complicated by local glacial plucking. Fairly intense fractures appear at and near the surface, but they are not considered of great consequence for the structure under consideration.

One potential geologic problem is evident at this stage of the investigation. The silts and sands below an elevation of minus 20 feet msl, in the area east of the navigation channel where a temporary bypass channel might be provided at the time of the construction, may scour and tend to undermine the barrier foundation to the east. Trouble is not anticipated, however, unless tidal movement is confined sufficiently to raise bottom velocities above the rate of 3.5 feet per second predicted from hydraulic studies. This velocity would have to occur immediately adjacent to the bottom. Particle size analyses of samples from this depth indicate a mean diameter grain size slightly larger than would be removed from place. Current observations taken within a meter of the bottom in the bypass channel would help to anticipate whether or not it will be necessary to take preventive measures against detrimental scour as construction progresses.

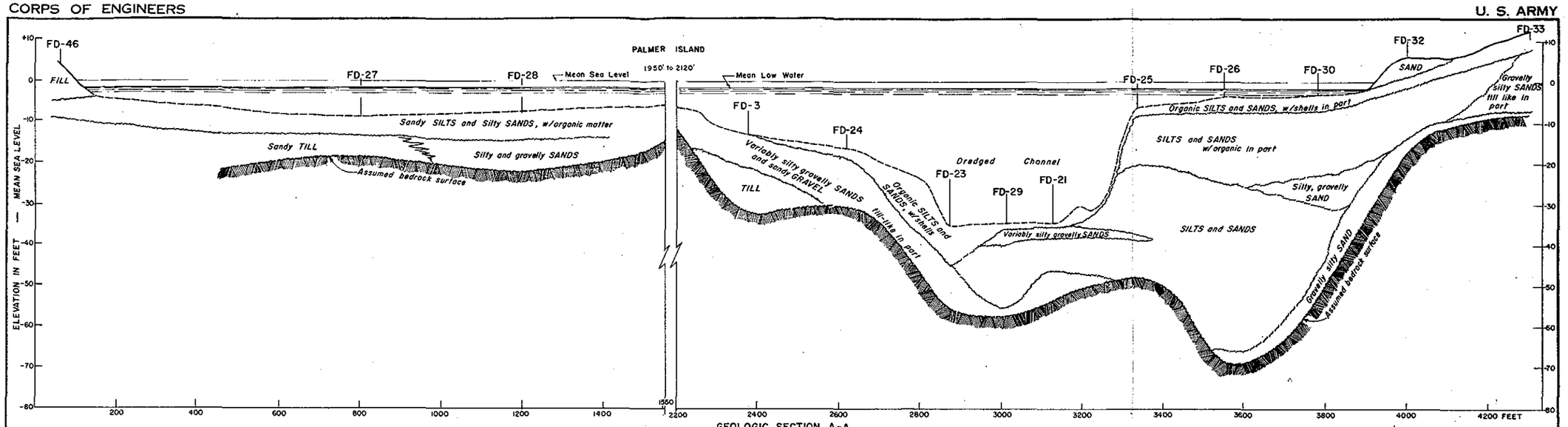
Settlement of the barrier will be predominantly east of the ship channel. Dredging of a bypass channel in this area will require backfilling with more suitable materials, thus alleviating the settlement condition to some extent.

The shallow rock and overlying granular and till-like materials west of Palmer Island will provide firm foundations with low-settlement values. Surface mud on the crossing, however, will be displaced for a few feet.

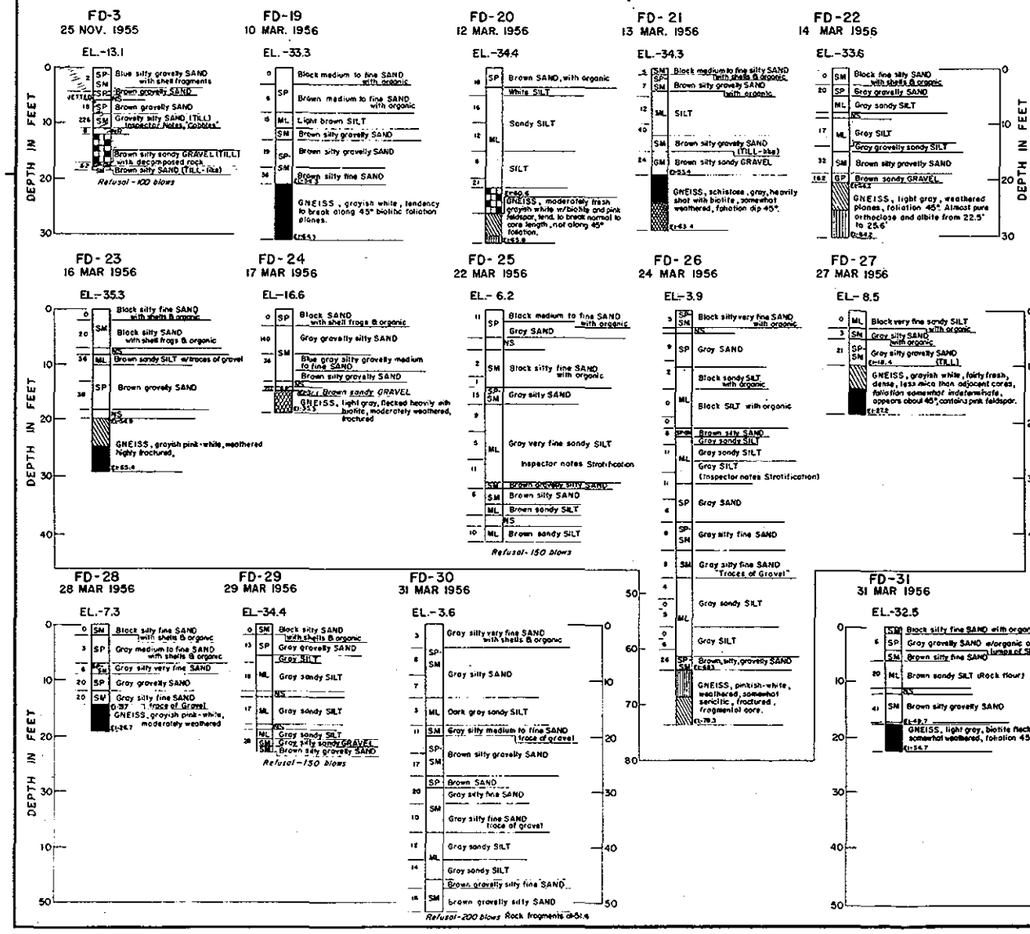
Granular materials with till or bedrock at shallow depths provide favorable land dike foundations throughout, with the exception of the unsuitable fill area, at the head of Clark Cove, which should be removed.

CORPS OF ENGINEERS

U. S. ARMY



GEOLOGIC SECTION A-A



LEGEND FOR GRAPHIC LOGS

FD-32 Type and number of exploration

4 APR 1956 Date exploration completed

EL.+6.0 M.S.L. elevation of ground surface or river bottom at time of exploration.

SP Group letter symbol according to Unified Soils Classification System.

NR No Recovery or unsatisfactory soil samples recovered.

NS Not Sampled. (Core-drilled, blasted, and/or wash-bored).

23 Blows per foot of penetration considered most representative usually within a 5-foot sample drive using a 350-pound hammer with a free fall of about 18 inches on a 2" I.D., 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.

* Blow count not recorded or not considered representative.

Cobble or boulder (Core - drilled).

Cobbles or boulders, continuous or nested (Core - drilled and/or blasted and chopped).

EL-17.6 Elevation of bedrock surface

Rock core recovery 0 - 25 %

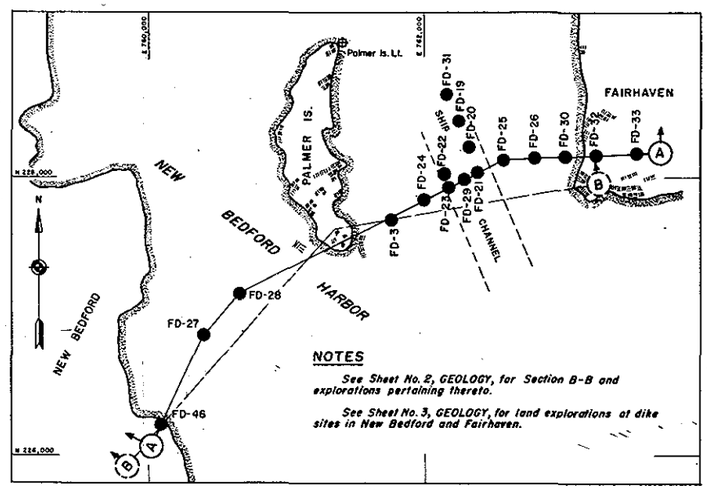
Rock core recovery 25 - 50 %

Rock core recovery 50 - 75 %

Rock core recovery 75 - 90 %

Rock core recovery 90 - 100 %

EL-28.0 Elevation at bottom of exploration



PLAN

SCALE IN FEET

400' 0 400' 800'

NOTES

See Sheet No. 2, GEOLOGY, for Section B-B and explorations pertaining thereto.

See Sheet No. 3, GEOLOGY, for land explorations at dike sites in New Bedford and Fairhaven.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS

HURRICANE SURVEY

NEW BEDFORD – FAIRHAVEN

MASSACHUSETTS

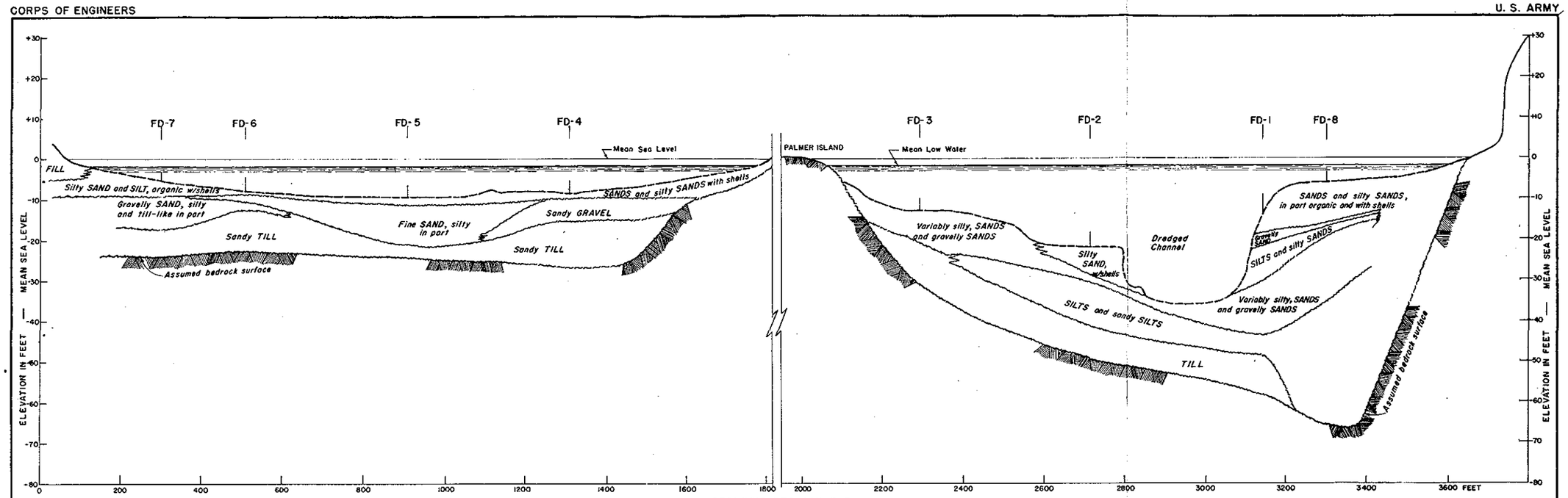
GEOLOGY

PREPARED BY C.G.N.
DRAWN BY C.G.B.
CHECKED BY R.G.C.
K. A. Fisk
CHIEF, N.E. LABORATORIES
F. Shuleit
CHIEF, N.E. HURRICANE UNIT
SUBMITTED BY
CHIEF, ENGINEERING DIV.
APPROVED BY
CHIEF ENGINEERING DIV.
APPROVED
LT. COL. C.E. ASSETO DIVISION ENGINEER
DATE DEC. 1956
SCALE AS SHOWN
DRAWING NUMBER NBFA - 2- 1000
SHEET 1 OF 4

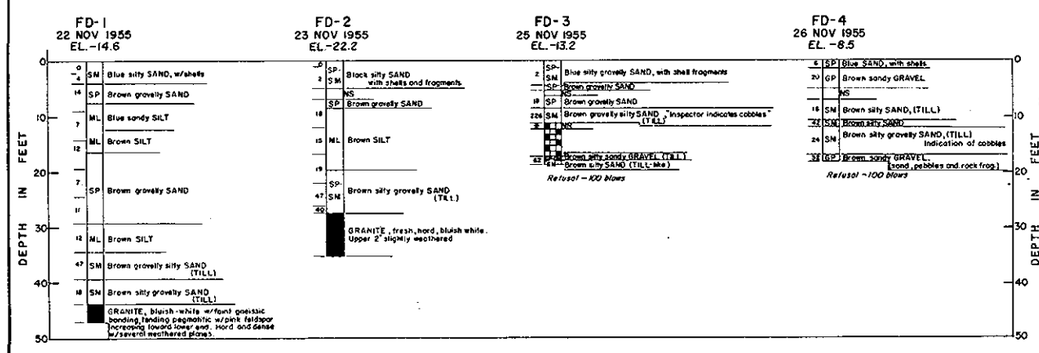
TO ACCOMPANY REPORT DATED 8 FEB. 1957

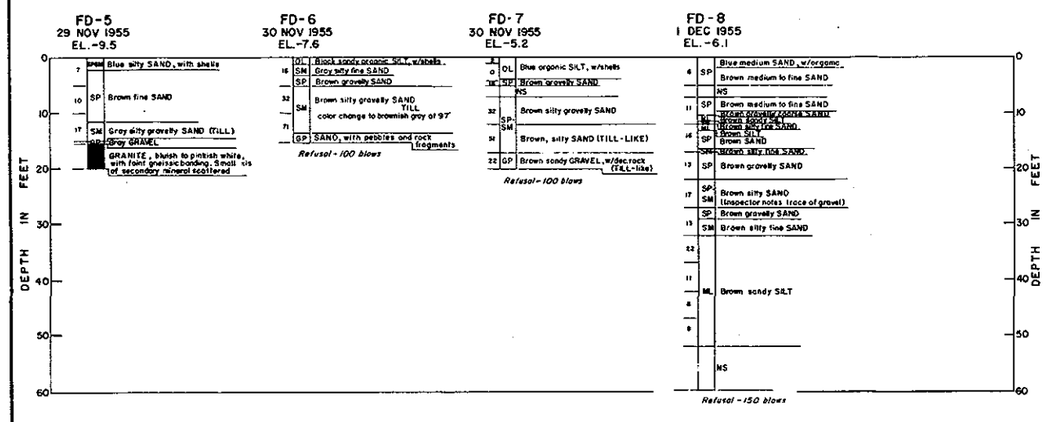
PLATE A-1

CORPS OF ENGINEERS — U. S. ARMY

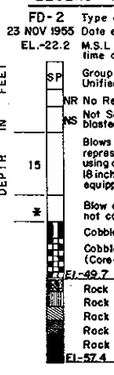


GEOLOGIC SECTION B-B

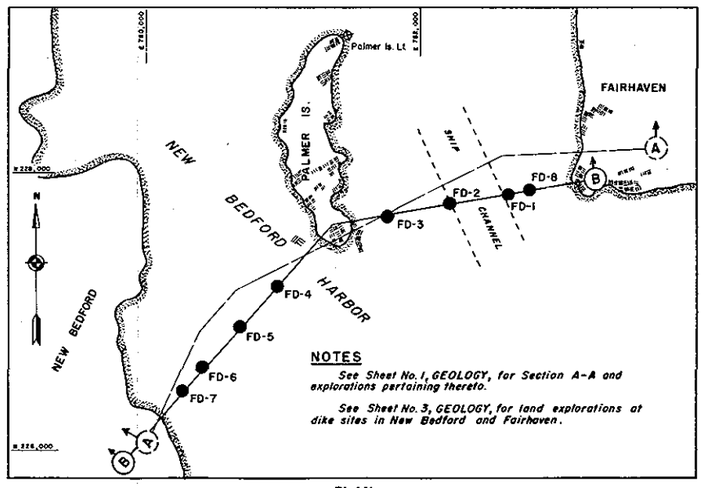




LEGEND FOR GRAPHIC LOGS



FD-2 — Type and number of exploration.
23 NOV 1955 — Date exploration completed.
EL.-22.2 — M.S.L elevation of river bottom at time of exploration.
SP — Group letter symbol according to Unified Soils Classification System.
NR — No Recovery or unsatisfactory soil samples recovered
NS — Not Sampled (Core-drilled blasted, and/or wash-bored).
15 — Blows per foot of penetration considered most representative usually within a 5-foot sample drive using a 350 pound hammer with a free fall of about 18 inches on a 2$\frac{1}{2}$" I.D., 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.
W — Blow count not recorded or not considered representative.
Cobble or boulder (Core-drilled).
Cobbles or boulders, continuous or nested (Core-drilled and/or blasted and chopped).
El.-49.7 Elevation of bedrock surface.
Rock core recovery 0-25 %
Rock core recovery 25-50 %
Rock core recovery 50-75 %
Rock core recovery 75-90 %
Rock core recovery 90-100 %
El.-57.4 Elevation at bottom of exploration



NOTES

See Sheet No. 1, GEOLOGY, for Section A-A and explorations pertaining thereto.

See Sheet No. 3, GEOLOGY, for land explorations at dike sites in New Bedford and Fairhaven.

PLAN

SCALE IN FEET
400' 0 400' 800'

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

PREPARED BY C.C.H.
DRAWN BY C.C.B.
CHECKED BY R.C.C.
CHIEF, N.E.D. LABORATORIES
CHIEF, N.E. HURRICANE UNIT
APPROVED BY
CHIEF ENGINEERING DIV.

HURRICANE SURVEY
NEW BEDFORD – FAIRHAVEN
MASSACHUSETTS
GEOLOGY

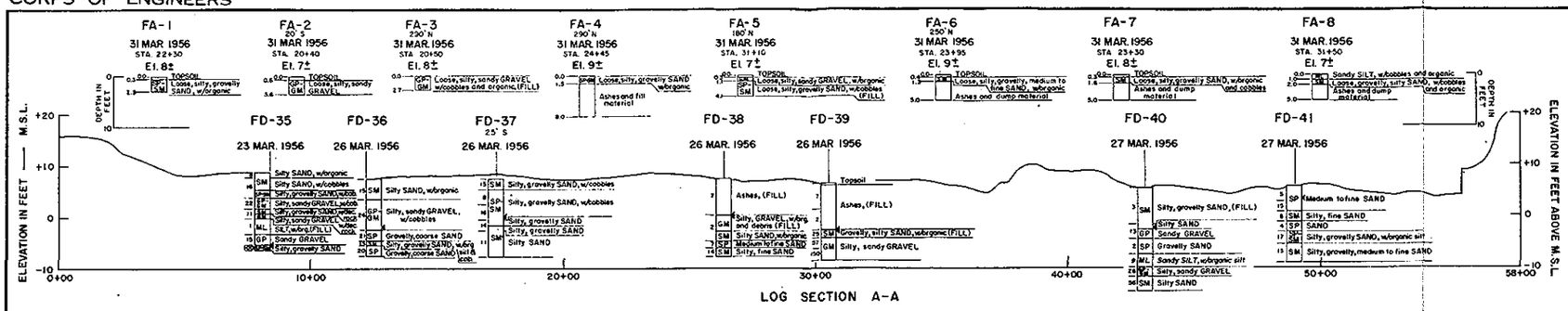
APPROVED
LT. COL., C.E. ASST. TO DIVISION ENGINEER
DATE DEC. 1956

TO ACCOMPANY REPORT DATED 8 FEB. 1957

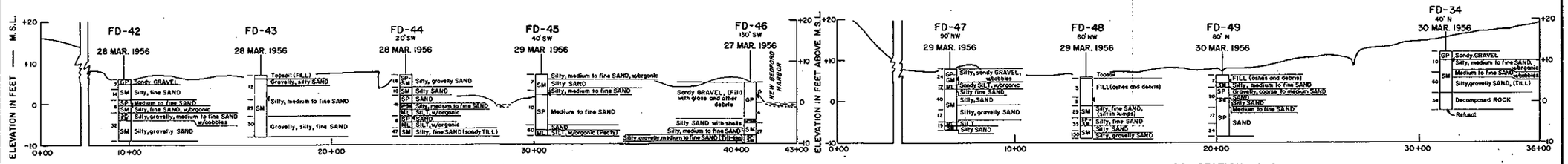
SCALE AS SHOWN
DRAWING NUMBER
NBFA - 2-1001
SHEET 2 OF 4

PLATE A-2

CORPS OF ENGINEERS — U. S. ARMY

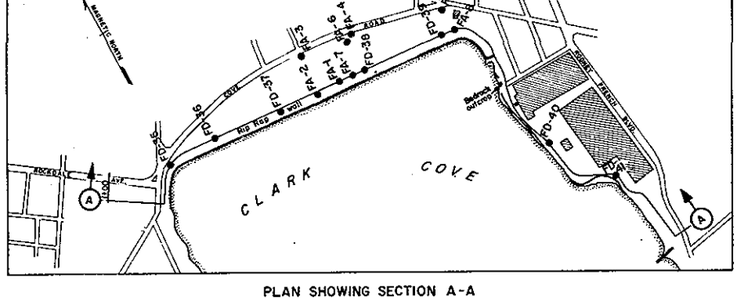


LOG SECTION A-A



LOG SECTION B-B

LOG SECTION C-C



PLAN SHOWING SECTION A-A
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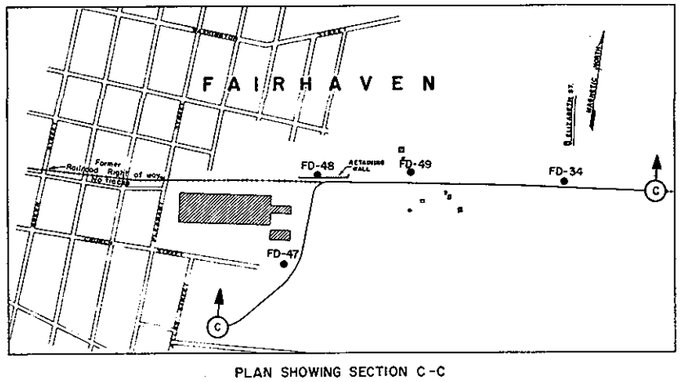

PLAN SHOWING SECTION C-C
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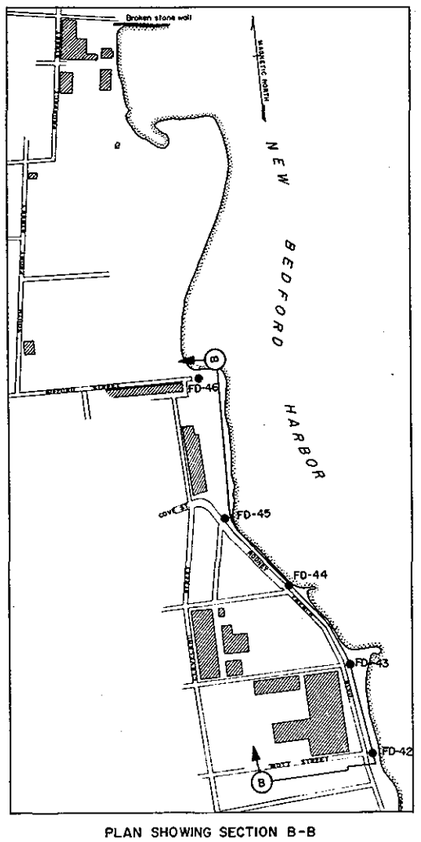

PLAN SHOWING SECTION B-B
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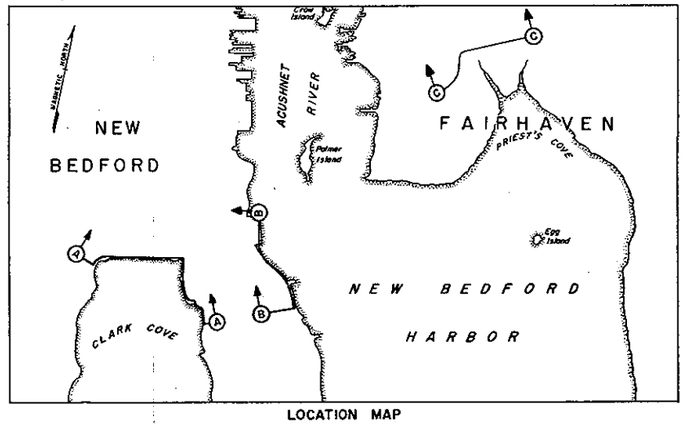


LOCATION MAP
SCALE IN FEET
1000 500 0 1000 2000 3000

LEGEND FOR GRAPHIC LOGS

FD-40 / FA-4	Foundation Drive — Sample Boring and number. Foundation Auger Boring and number.
STA. 24+45	Location by Station
290' N.	Offset
27 MAR. 1956	Date exploration completed.
El 9±	Approximate M.S.L. elevation of ground surface at time of exploration.
▽	Subsurface water level in boring at time of exploration.
ML	*Group letter symbol according to* Unified Soil Classification System.
NR	No Recovery or unsatisfactory soil samples recovered.
NS	Not Sampled (Core-drilled, blasted and/or wash-bored).
56	Blows per foot of penetration considered most representative, usually within a 5-foot sample drive using a 350 pound hammer with a free fall of about 18 inches on 2" to 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.
*	Blow count not recorded or not considered representative.
	Cobbles or boulders (Core-drilled).
	Cobbles or boulders continuous or nested. (Core-drilled and/or blasted and chopped.)
El	Elevation of bedrock surface.
	Rock core recovery 0 - 25 %
	Rock core recovery 25 - 50 %
	Rock core recovery 50 - 75 %
	Rock core recovery 75 - 90 %
	Rock core recovery 90 - 100 %
El	Elevation at bottom of exploration.

NOTE

See Sheet Nos. 1 and 2, GEOLOGY, for explorations and geologic sections on alignments from Fairhaven to New Bedford through Palmer Island.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS.

PREPARED BY H.H.B., Jr.
DRAWN BY H.C.S.
CHECKED BY H.H.B., Jr.
CHIEF, H.E.D. LABORATORIES
CHIEF, H & B HURRICANE UNIT
SUPERVISED BY
CHIEF, PLANS & SPECIFICATION
APPROVED
CHIEF ENGINEERING DIV.
APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

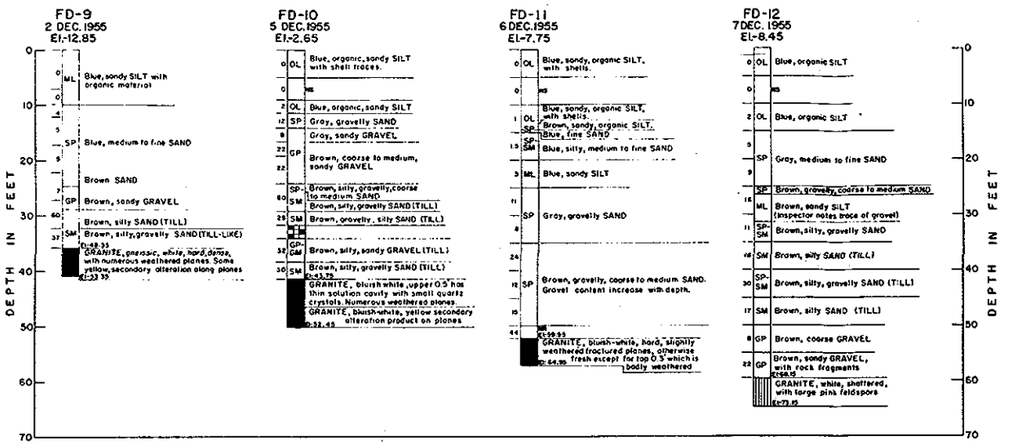
HURRICANE SURVEY
NEW BEDFORD — FAIRHAVEN
MASSACHUSETTS
GEOLOGY

DATE DEC. 1956
SCALE AS SHOWN
TO ACCOMPANY REPORT DATED 8 FEB. 1957
DRAWING NUMBER NBFA-2-1002
SHEET 3 OF 4

PLATE A-3

CORPS OF ENGINEERS

U. S. ARMY



LEGEND FOR GRAPHIC LOGS

FD-10 — Foundation Test Boring and number

5 DEC 1955 — Date exploration completed.

El-2.65 — M.S.L. elevation of ground or river bottom at time of exploration.

Subsurface water level in boring at time of exploration.

SM — Group letter symbol according to Unified Soil Classification System.

NR — No Recovery or unsatisfactory soil samples recovered.

NS — Not Sampled (Core-drilled, blasted and/or wash-bored).

80 — Blows per foot of penetration considered most representative, usually within a 5-foot sample drive using a 350 pound hammer with a free fall of about 18 inches on a 2" O.D. or 1⅜" I.D. size sample spoon equipped with beveled and sharpened drive shoe. 2½" O.D. sample spoon used for FD-18.

Blow count not recorded or not considered representative.

Cobbles or boulders (Core-drilled).

Cobbles or boulders continuous or nested. (Core-drilled and/or blasted and chopped.)

El-43.75 — Elevation of bedrock surface.

Rock core recovery 0 – 25 %

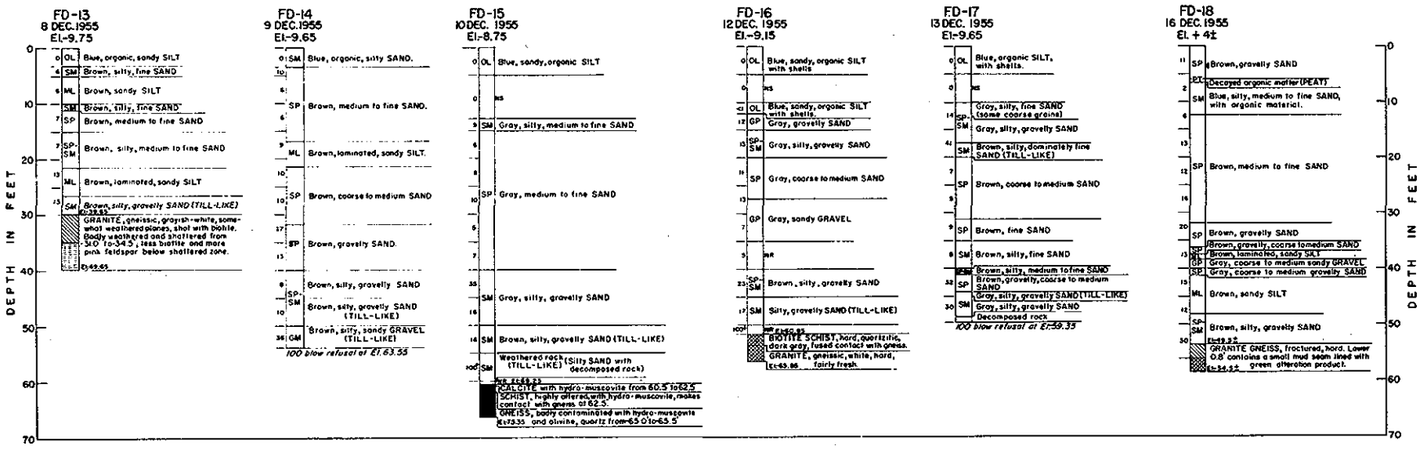
Rock core recovery 25 – 50 %

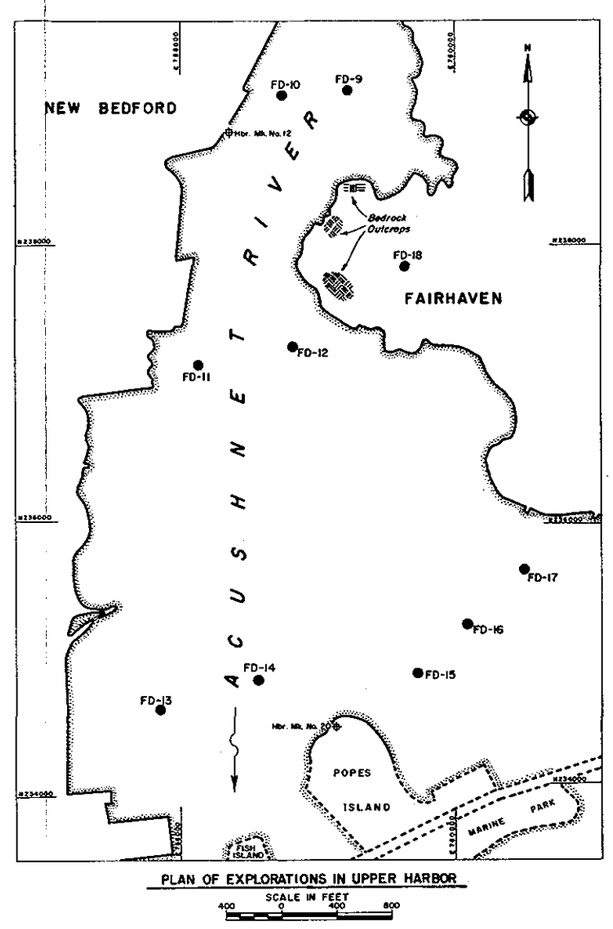
Rock core recovery 50 – 75 %

Rock core recovery 75 – 90 %

Rock core recovery 90 – 100 %

El-52.45 — Elevation at bottom of exploration.





PLAN OF EXPLORATIONS IN UPPER HARBOR

SCALE IN FEET

400 0 400 800

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

PREPARED BY C.G.M.
DRAWN BY H.C.S.
CHECKED BY H.C.S.
K.G. Isaak
CHIEF N.E.D. LABORATORIES
CHIEF, N.E. HURRICANE UNIT
SUBMITTED BY
APPROVED FOR THE DIVISION ENGINEER
APPROVED
ACTING DIVISION ENGINEER

HURRICANE SURVEY

NEW BEDFORD – FAIRHAVEN

MASSACHUSETTS

GEOLOGY

DATE DEC. 1956

TO ACCOMPANY REPORT DATED 8 FEB. 1957

SCALE AS SHOWN

DRAWING NUMBER NBFA-2-1003

SHEET 4 OF 4

PLATE A-4

APPENDIX B

HYDROLOGY AND HYDRAULICS

APPENDIX B

HYDROLOGY AND HYDRAULICS

INTRODUCTION

B-1. This appendix presents data to supplement the sections of the main report relating to the subjects of hydrology and hydraulics. It includes a summary of temperature and precipitation data to amplify the section of the report on "Climatology," a summary of streamflow data to support "Design Runoff," and data on hurricane wind velocities, rainfall values, and barometric pressures to augment report material on the history and frequency of hurricanes. Computations of pool buildup and detailed analyses of wave height, runup, overtopping, and current velocities are also included in this appendix.

HYDROLOGY

B-2. TEMPERATURE

Mean, maximum, and minimum monthly temperatures at New Bedford for 68 years of record are indicated in Table B-1, below.

TABLE B-1

MEAN MONTHLY TEMPERATURES (1888-1955)

New Bedford, Massachusetts

	Degrees Fahrenheit				Degrees Fahrenheit			
Month	Mean	Maximum	Minimum		Month	Mean	Maximum	Minimum
Jan	30.0	39.6	21.3		July	71.2	78.0 (2)	63.4
Feb	29.5	37.5	20.6 (1)		Aug	69.6	76.0	61.6
Mar	36.8	44.8	29.0		Sep	63.6	70.2	55.4
Apr	46.4	53.2	37.6		Oct	53.7	61.4	44.0
May	56.6	64.2	48.4		Nov	43.6	50.4	35.2
June	65.3	73.2 (2)	57.0		Dec	33.0	40.9	25.1
					Annual	49.9		

(1) Extreme minimum, -12°F. on 22 Feb 1934.
(2) Extreme maximum, 97°F. on 8 July 1937 and 26 June 1952.

B-3. PRECIPITATION

Monthly means and extremes of precipitation at New Bedford, for 142 years of record, are summarized in Table B-2 below.

TABLE B-2

MONTHLY PRECIPITATION, (1814-1955)

New Bedford, Massachusetts

	Inches				Inches		
Month	Mean	Maximum	Minimum	Month	Mean	Maximum	Minimum
Jan	3.92	10.75	0.77	July	3.08	12.00	0.02
Feb	3.68	8.30	0.91	Aug	4.18	18.72(2)	0.24
Mar	4.12	9.77	0.09	Sep	3.39	12.06	0.21
Apr	3.83	9.27	0.91	Oct	3.69	10.09	0.15
May	3.71	9.80	0.57	Nov	4.08	9.74	0.35
June	3.05	9.31	0.01 (1)	Dec	3.96	10.05	0.45
				Annual	44.71	65.41(3)	28.04 (4)

(1) June 1949. (3) 1829.
(2) August 1826. (4) 1930.

B-4. RUNOFF AND STREAMFLOW.

There are no streamflow records for the Acushnet River. Estimates of flow have been made based on available data for the neighboring Wading River. The drainage areas of both these rivers are similar and their rates of runoff are comparable. A summary of peak flows recorded at the two gages on the Wading River and estimated data for the ungaged Acushnet River are contained in Table B-3 on the following page. A low rate of discharge is characteristic of both the Wading and Acushnet River Basins. The peak discharge recorded at Norton, Massachusetts, in the Wading River Basin, during the August 1955 flood was 27.6 cfs per square mile whereas flows of over 500 cfs per square mile were experineced in a number of other New England rivers during this same flood.

Discharge hydrographs of the Wading River at Norton and West Mansfield, Massachusetts, for the August 1955 ("Diane") flood, together with a hyetograph of the rainfall at Mansfield on 17, 18, and 19 August, are shown on Plate B-1. The computed hydrograph for the Acushnet River at Saw Mill Dam, New Bedford, is derived from an analysis of recorded discharges on the Wading River and drainage-area relationships. The computation is made as follows:

Saw Mill Dam Q = (Norton Q - West Mansfield Q) $\left(\frac{18.4}{42.4 - 19.2}\right)$, where Q equals discharge in cfs and the figures indicate the respective drainage areas in square miles.

The Wading River discharges are often affected by the regulation of ponds at upstream power plants, and, occasionally, by diversion of water for the municipal supply of Attleboro, Massachusetts. However, in the 12 hours prior to the peak of the August 1955 flood there was no upstream regulation or diversion.

TABLE B-3

STREAMFLOW DATA

Wading and Acushnet Rivers, Massachusetts

River and Location	Drainage Area (sq.mi.)	Period of Record	Peak Discharge (cfs)	Peak Discharge (cfm)(1)	Date
Wading River, at Norton	42.4	June 1925 to Date	1172	27.6	20 Aug 1955
			1030	24.2	12-13 Mar 1936
			843	19.9	6 June 1931
Wading River at West Mansfield	19.2	Oct 1953 to Date	517	27.0	20 Aug 1955
Acushnet River at New Bedford (Saw Mill Dam)	18.4	-	650(2)	35.0(2)	20 Aug 1955

(1) cfs per square mile.
(2) Estimated.

B-5. DRAINAGE AREAS.

The total drainage area of the Acushnet River and New Bedford Harbor above the proposed barrier at Palmer Island (Plan "F") is 28.4 square miles. This includes 18.4 square miles above Saw Mill Dam. Below the dam there is 5.0 square miles of urban area, 3.3 square miles of suburban area, and 1.7 square miles (1,070 acres) of water surface, a total of 10.0 square miles. The urban and suburban areas contributing runoff to the pool behind the main harbor barrier are shown on Plate B-2.

B-6. HURRICANE RAINFALL

The greates rainfalls associated with hurricanes in New England are those recorded for "Connie" and "Diane" in August 1955. Hurricane "Connie," 11-15 August, caused rainfall varying from about four to six inches over southern New England and ended a period of drought. A week later, on 17-20 August, Hurricane "Diane" brought rainfall of 16 to 20 inches over Massachusetts. Although New Bedford did not receive excessive rainfall in either of these storms, Hurricane "Diane" did cause a record fall of 13.1 inches in 55 hours (4.1 inches in 6 hours) at Mansfield, 25 miles north of New Bedford. The recorded rainfall at New Bedford in a number of recent hurricanes are tabulated in Table B-4 on the following pages. Values of rainfall at other New England locations which may be considered indicative of amounts that can occur in the New Bedford area are shown on the same table.

According to the U.S. Weather Bureau (Hydrometeorological Bulletin No. 33) the maximum possible rainfalls for 6-hour and 12-hour periods are 25.0 and 27.6 inches, respectively, for a 10-square-mile area, and 22.1 and 25 inches, respectively, for a 30-square-mile area.

Mass curves of Hurricane "Diane" rainfall (17-20 August 1955), for the recorder station at Blue Hill, Massachusetts, and mass curves for Mansfield, Massachusetts, derived from Blue Hill records, are shown on Plate B-3. As a matter of interest, the group of mass curves on Plate B-4 shows the rainfall in various major storms at a number of locations and affords a comparison of the magnitude and intensity of these rainfalls with those of a Standard Project Storm and a Maximum Possible Storm for a 200 square-mile drainage area.

B-7. HURRICANE WINDS

The most reliable data on experienced hurricane wind velocities in New England begin with the September 1938 hurricane. The maximum velocity in New England during this storm was a recorded gust of 185 mph at the Blue Hill Observatory in Milton, Massachusetts, 40 miles north of New Bedford, where a sustained 5-minute wind of 121 mph was also recorded. At other locations in southern New England, sustained 5-minute velocities ranging from 38 to 87 mph were experienced.

During the hurricane of 14 September 1944, a maximum gust of 104 mph was registered at Chatham, Massachusetts, 45 miles east of New Bedford. Sustained 5-minute velocities of from 33 to 82 mph were recorded at a number of locations along the New England coast during this hurricane. At Westerly, Rhode Island, the calm during the passing of the "eye" of the storm was clearly noted.

TABLE B-4

HURRICANE RAINFALLS

New Bedford, Massachusetts, and Other New England Locations

Location	Accumulated Rainfall in Inches 6 hr.	12 hr.	24 hr.	Storm Total
17-20 August 1955 - Hurricane "Diane"				
New Bedford, Mass.	1.2	1.2	2.9	3.9 (35 hr)
Westfield, Mass.	7.9	10.9	15.7	19.8 (48 hr)
Holyoke, Mass.	6.0	9.6	13.2	15.0 -
Mendon, Mass.	6.4	7.8	10.5	13.8 (56 hr)
Milton, Mass. (Blue Hill Observatory)	5.5	8.3	9.9	13.8 (57 hr)
Mansfield, Mass.	4.1	5.8	8.5	13.1 (55 hr)
Norfolk, Conn.	5.9	7.8	10.0	12.1 (46 hr)
11-15 August 1955 - Hurricane "Connie"				
New Bedford, Mass.	1.5	4.0	4.2	4.3 (43 hr)
Norfolk, Conn.	2.1	3.0	5.4	8.7 (78 hr)
11 September 1954 - Hurricane "Edna"				
New Bedford, Mass.	2.8	3.3	-	3.4 (15 hr)
Quonset Point, R.I.	-	-	-	8.7 (15 hr Est'd)
Woonsocket, R.I.	4.8	5.8	-	6.3 (15 hr)
30-31 August 1954 - Hurricane "Carol"				
New Bedford, Mass.	1.4	1.9	-	1.9 (13 hr)
Mendon, Mass.	4.3	4.9	-	5.1 (15 hr)
15 August 1953 - Hurricane "Barbara"				
New Bedford, Mass.	3.5	4.0	4.1	4.2 (26 hr)
East Wareham, Mass.	-	-	4.7	4.7 -
Plymouth, Mass.	-	-	4.7	4.7 -

TABLE B-4 (Cont'd)

HURRICANE RAINFALLS

New Bedford, Massachusetts, and Other New England Locations

Location	Accumulated Rainfall in Inches			
	6 hr.	12 hr.	24 hr.	Storm Total
12-15 September 1944				
New Bedford, Mass.	1.7	1.9	2.1	3.4 (53 hr)
Bridgeport, Conn.	-	-	5.8	10.7 -
New Haven, Conn.	3.9	4.0	4.0	8.5 (57 hr)
Newington, Conn.	5.3	5.3	5.4	7.7 (54 hr)
17-21 September 1938				
New Bedford, Mass.	0.4	0.7	1.1	2.2 -
Camp Buck, Conn.	-	-	-	17.1 -
Barre, Mass.	-	-	-	17.0 -
Springfield, Mass.	3.2	4.4	6.3	10.4 (95 hr)

In southern New England, during Hurricane "Carol" (31 August 1954), gusts of 125 and 130 mph were experienced at locations 40 miles north and 45 miles southwest of New Bedford. Sustained 1-minute velocities ranging from 38 to 93 mph were registered.

Recorded wind velocities at locations in southern New England, for the three great hurricanes of 1938, 1944, and 1954, are given in Table B-5 on the following page.

B-8. HURRICANE BAROMETRIC PRESSURES

The center, or "eye" of the 1938 hurricane entered Connecticut about 5 miles west of New Haven (105 miles west of New Bedford) at about 3:30 P.M., EST, on 21 September and then proceeded northwesterly at a rate of from 50 to 60 mph. The lowest pressure registered during the passage of this storm was 28.04 inches at Hartford, Connecticut.

In the hurricane of 14 September 1944, the "eye" of the storm passed over Westerly on the south coast of Rhode Island, (50 miles west of New Bedford) at about 10:00 P.M., EST. It then continued in a northeasterly direction veering out to sea at Boston, Massachusetts. The minimum recorded barometric pressure in southern New England during this storm was 28.30 inches at Westerly. A low of 28.42 inches was experienced at New Bedford.

TABLE B-5

HURRICANE WINDS

New Bedford, Massachusetts, and Other New England Locations

Location	Velocity in Miles per Hour: Sustained 5-Min.	Sustained 1-Min.	Maximum Gust	Direction
Hurricane of 21 September 1938				
New Bedford, Mass.	60	-	-	-
Milton, Mass. (Blue Hill Observatory)	121	-	186	S
Providence, R.I.	87	-	95	SW
Block Island, R.I.	82	-	91	SE
Boston, Mass.	73	-	87	S
Nantucket, Mass.	52	-	57	SE
Hartford, Conn.	46	-	59	NE
New Haven, Conn.	38	-	46	NE
Hurricane of 14 September 1944				
New Bedford, Mass.	-	-	85	-
Chatham, Mass.	-	-	104	-
Fall River, Mass.	-	-	90	-
Block Island, R.I.	82	-	88	SE
Nantucket, Mass.	57	-	79	SW
Westerly, R.I.	-	-	75	-
New London, Conn.	-	-	70	-
Hartford, Conn.	50	-	62	N
Providence, R.I.	43	-	49	SE
New Haven, Conn.	33	-	38	N
Hurricane of 31 August 1954 "Carol"				
New Bedford, Mass.	-	-	85	-
Block Island, R.I.	-	93	130	SE
Blue Hill, Mass.	-	93	125	SE
Providence, R.I.	-	90	105	ESE
Boston, Mass.	-	86	100	SE
Nantucket, Mass.	-	72	77	SE
Hartford, Conn.	-	56	64	NE
New Haven, Conn.	-	38	65	NE
Bridgeport, Conn.	-	-	60	-

The center of Hurricane "Carol" (31 August 1954) crossed the south shore of Connecticut in the vicinity of New London (65 miles west of New Bedford) at about 10:30 A.M., EST, and then followed a general northwesterly path across New England. The minimum barometric pressures in New England upon the occasion of this hurricane were 28.20 inches at Storrs, Connecticut, (30 miles north of New London) and 28.26 inches at New London.

The minimum pressures recorded at a number of New England locations during these three great hurricanes of the past 18 years are given in Table B-6 on the following page.

B-9. HURRICANE TIDAL-FLOOD LEVELS

The heights of tidal flooding experienced at a number of locations in New Bedford, Fairhaven, and Acushnet during Hurricane "Carol" (1954) were obtained during the course of the damage-survey work in the field. The elevation of these flood levels, referred to mean sea level, were then determined by a field level party. This information was supplemented by material on high water levels collected by this office after the September 1938 hurricane and elevation data furnished by the New Bedford Department of Public Works on observed flood levels in the hurricane of 1938, 1944, and 1954. Based on this information, profiles have been prepared of the 1938 and 1954 tidal-flood elevations between the south end of Clark Point and the head of tidewater in the Acushnet River at Saw Mill Dam. (See Plate B-5). These profiles indicate a general level of flooding in the harbor area below the New Bedford-Fairhaven Bridge of 12.5 feet msl in 1938 and 11.9 feet msl in 1954. They also indicate that flooding reached elevations of 13.3 and 12.7 feet msl in 1938 and 1954, respectively, at the head of tidewater in the Acushnet River three miles above the bridge.

B-10. POOL BUILDUP

The volumes of runoff contribution to the pool behind the harbor barrier in Plan "F," for various periods of gate closure, are summarized in Table B-7. The heights of rise in the harbor resulting from the storage of this runoff are also shown in the table. It is interesting to note that the runoff from 5.0 square miles of urban area accounts for one-half, or 1.6 feet, of the total 3.2-foot rise in a 12-hour gate closure period. The runoff from the 18.4 square-mile drainage area of the Acushnet River accounts for 0.6-foot of the total rise; the suburban area, 0.4 foot; and the water surface area, 0.6 foot.

TABLE B-6

MINIMUM BAROMETRIC PRESSURES

New England Hurricanes of 1938, 1944, and 1954

Location	Time (EST)	Barometer (inches)
Hurricane of 21 September 1938		
Block Island, R.I.	3:05 P.M.	28.66
Providence, R.I.	3:30 P.M.	28.90
Nantucket, Mass.	3:30 P.M.	29.39
New Haven, Conn.	3:50 P.M.	28.11
Bridgeport, Conn.	-	28.30
Hartford, Conn.	4:17 P.M.	28.04
Boston, Mass.	5:30 P.M.	29.09
Northfield, Vt.	7:30 P.M.	28.77
Burlington, Vt.	8:00 P.M.	28.68
Hurricane of 14 September 1944		
New Haven, Conn.	8:50 P.M.	28.86
Hartford, Conn.	9:50 P.M.	28.94
Westerly, R.I.	10:00 P.M.	28.30
Block Island, R.I.	10.09 P.M.	28.34
Fall River, Mass.	10:30 P.M.	28.53
Worcester, Mass.	10:50 P.M.	28.92
Providence, R.I.	11:20 P.M.	28.56
Nantucket, Mass.	11:28 P.M.	29.04
New Bedford, Mass.	11:45 P.M.	28.42
Hurricane of 31 August 1954		
New Haven, Conn.	9:10 A.M.	28.77
New London, Conn.	10:00 A.M.	28.26
Providence, R.I.	10:45 A.M.	28.69
South Weymouth, Mass.	10:50 A.M.	28.68
Storrs, Conn.	11:00 A.M.	28.20
Falmouth, Mass.	11:00 A.M.	29.17
Boston, Mass.	12:00 Noon	28.83
Burlington, Vt.	3:40 P.M.	29.32

TABLE B-7

POOL BUILDUP WITH DESIGN RUNOFF

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

Gate Closure Period		6-hour		9-hour		12-hour	
Runoff Area	Area (sq.mi)	Volume of Runoff (inches)	(ac.ft.)	(inches)	(ac.ft.)	(inches)	(ac.ft.)
Acushnet River	18.4	0.33	323	0.50	490	0.66	646
Suburban	3.3	3.00	528	3.18	559	3.40	598
Urban	5.0	6.00	1,600	6.35	1,694	6.80	1,813
Water Surface	1.7	7.00	634	7.30	661	7.60	688
			3,085		3,404		3,745
		Rise in Feet of Water Level(1)					
		2.7		2.9		3.2	

(1) Above elevation of water surface at time when navigation gates and the conduit through the barrier are closed.

The heights of rise in New Bedford Harbor for various volumes of runoff, as shown in Table B-7, have been determined by utilization of the area capacity curves shown on Plate B-6. These curves are predicated on the assumption of a straight-line variation in area from elevation zero to 10 feet msl as derived from U. S. Geological Survey Maps.

Determinations also have been made of the ponding that would have been experienced behind the harbor barrier by reason of the fresh water runoff during the major hurricanes of 1938, 1944, and 1954. This was done in a manner similar to that employed for estimating the ponding under design runoff conditions. It has been estimated that gates in the barrier would have been closed 9 hours in the 1938 and 1954 hurricanes, and 8 hours in the 1944 hurricane, as indicated in the following tabulation:

Hurricane	Time of Closure (EST)	Time of Opening (EST)	Total Closure Time (hours)
21 Sept. 1938	1:00 P.M.	10:00 P.M.	9
14-15 Sept. 1944	5:00 P.M.	1:00 A.M.	8
31 Aug. 1954	4:30 A.M.	1:30 P.M.	9

The above times were determined by utilization of the tide curves shown on Plate B-7, and on assumption that the water surface at the time of closure was at mean sea level in 1938 and 1954, and at mean high water in 1944. It was assumed necessary to close at mean high water in the 1944 hurricane because the tide was at mean high water prior to arrival of the tidal surge. In the 1938 and 1954 hurricanes, however, the surge was beginning near low tide and closure was made at the time water surface was at mean sea level.

The volumes of fresh water that would have been ponded in the harbor area during the assumed gate closure periods, for each of the three recent great hurricanes, are summarized in Table B-8 on the following page. The rise in water level that would have been experienced by reason of this ponding is indicated also in the table.

TABLE B-8

POOL BUILDUP FROM RUNOFF IN PAST HURRICANES

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

		21 September 1938		14-15 September 1944		31 August 1954	
Gate Closure Period		9-hour		8-hour		9-hour	
Runoff Area	Area (sq.mi.)	Volume of Runoff (inches)	(ac.ft.)	(inches)	(ac.ft.)	(inches)	(ac.ft.)
Acushnet River	18.4	0.06	58	0.04	39	0.01	9
Suburban	3.3	0.09	16	1.05	184	1.47	258
Urban	5.0	0.09	24	1.05	279	1.47	392
Harbor Water Surface	1.7	0.09	8	1.05	95	1.47	133
			106		597		792
		Rise in Water Level in Feet (1)					
		0.1		0.5		0.7	

(1) Rise is above the elevation of water surface at time when navigation gates and the conduit through the barrier are closed. Water level at time of gate closure is assumed to be at msl in the 1938 and 1954 hurricanes, at mhw (1.8 feet msl) in the 1944 hurricane.

B-11. DESIGN STORM TIDE DERIVATION

A report dated March 1956, entitled "Dynamic Storm Tide Potential", prepared by the Department of Oceanography of Texas A. and M. College in connection with research work conducted by them for the Beach Erosion Board, contains computations of storm-tide potentials off Newport, Rhode Island, at the entrance to Narragansett Bay. These computed potentials for the 1938 and the design hurricane, are 6.9 feet and 8.6 feet, respectively. Using this information, a design storm-tide of 15 feet has been computed for New Bedford and Fairhaven Harbor, as follows:

Peak flood level, 1938 hurricane	12.5	feet msl
Predicated tide for time of 1938 peak	2.5	feet msl
Differential or storm surge	10	feet
1938 wind setup	2	feet*
Storm surge less wind setup (1938)	8	feet
Ratio of design to 1938 storm-tide potential, off Newport	1.25	*
Design storm surge, without wind setup	10	feet
Design storm wind setup	5	feet
Design storm tide or surge	15	feet

* From data furnished by Department of Oceanography, Texas A. & M., under contract with Beach Erosion Board

B-12. WAVE HEIGHTS AND RUNUP

Data on significant wave heights and wave runup described in the following paragraphs and tables have been prepared by the Beach Erosion Board for the proposed barrier, dikes, and walls of Plan "F." These have been predicated on a preliminary storm tide of 15.0 feet, a spring tide of 3.0 feet, and a wind velocity of 75 mph. The wind velocity of 75 mph is a 2-hour average over New Bedford Harbor in the design storm, that is, the September 1944 hurricane transposed to follow a path most critical to the New Bedford-Fairhaven area. Significant wave heights are the average of the highest one-third of the waves in a wave train. They will be exceeded by about 13 percent of all the waves in the train. The significant waves, under the assumed design conditions, have a period of 6.5 seconds. Data on wave heights and runup prepared by the Beach Erosion Board are summarized in Table B-9 on the following page. The runup figures in the table indicate the vertical rise of water above a still-water level of 18 feet msl in the design hurricane and 12.5 feet msl in the 1938 hurricane. The computation of runup values are based on walls of concrete construction and dikes with rubble slopes of rough angular stones.

TABLE B-9

WAVE HEIGHTS AND RUNUP

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

Location	Top Elev. (feet msl)	Slope	1938 Hurricane Significant Wave Height (1) (feet)	1938 Hurricane Wave Runup (2) (feet)	Design Hurricane Significant Wave Height (feet)	Design Hurricane Wave Runup (3) (feet)
			MAIN HARBOR BARRIER AND DIKE			
Dike extension along Blvd.	22	1 on 1.5	5	7.5	7	10
Barrier, west of channel	22	1 on 2.5	6	5.5	8	7
Navigation gate	22	Vertical	6	6.5	8	9
Barrier at channel	22	1 on 2.5	5	4.5	7	6
Barrier at Ft. Phoenix	22	1 on 2.5	4	4	5	4.5
			CLARK COVE DIKE			
West land wall	22	20 on 1	5	8.5	7	10
Dike, north side of cove	22	1 on 1.5	6	9	8	11
Dike, east side of cove	22	1 on 1.5	5	7.5	7	10

TABLE B-9 (Cont'd)

WAVE HEIGHTS AND RUNUP

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

Location	Top Elev. (feet msl)	Slope	1938 Hurricane Significant Wave Height (1) (feet)	1938 Hurricane Wave Runup (2) (feet)	Design Hurricane Significant Wave Height (feet)	Design Hurricane Wave Runup (3) (feet)
				FAIRHAVEN DIKE		
West wing	20	1 on 1.5	2	3.5	3	4
Center section	20	1 on 1.5	3	6	4	6.5
East section	20	1 on 1.5	2	3.5	3	4

(1) Determined by multiplying the significant wave height in the design hurricane by 56/75 where 56 is wind velocity in 1938 hurricane and 75 is velocity in design hurricane.

(2) Above still-water level of 12.5 feet msl.

(3) Above still-water level of 18.0 feet msl.

Maximum wave heights will be approximately 1.6 times greater than the significant wave heights noted in Table B-9 and corresponding wave runup also will be greater than indicated. Runup data were derived by the Beach Erosion Board from curves which represent the results of laboratory studies.

B-13. OVERTOPPING

The amount of overtopping is important not only for the design of a safe structure but also from the standpoint of flooding from the overtopping water. Rates of overtopping were determined for a peak still-water level of 18 feet msl and for several lower elevations in a design storm. The significant wave heights in a design hurricane, shown in Table B-9, were used in all of the computations. The duration of overtopping is estimated from a hypothetical tide graph based on tide graphs for the 1938, 1944, and 1954 hurricanes. Furthermore, the assumption is made that overtopping ceases at the time peak still-water level is reached. This is based on the premise that the hurricane winds which generate the storm tide and waves rapidly lose their force after the peak of the tidal-surge is reached. This subsidence of the wind permits the water level to fall rapidly. The rapid decrease in wind velocity experienced upon the passing of a hurricane was recorded by the New Bedford Public Works Department upon the occasion of the September 1944 hurricane. In determining the volume of overtopping for rubble slopes of 1 on 1.5 and 1 on 2.5, curves derived by the Beach Erosion Board were used. Curves for overtopping of vertical walls, contained in Beach Erosion Board Technical Manual No. 64, were applied in estimating the degree of overtopping for concrete walls with a slope of 20 on 1. The curves that were employed relate the rate of overtopping in cubic feet per second per foot of length to the crest elevation above still-water, with significant wave heights as a third variable.

A key to the relative importance of overtopping of proposed protective structures in the 1938 and design hurricanes may be found in Table B-9. It may be noted that little or no overtopping is indicated in the event of a recurring 1938 hurricane. Under such conditions, the maximum wave runup at the Main Harbor Barrier and at Clark Cove Dike is nine feet. This gives a maximum elevation of 21.5 feet msl for the top of wave runup, or 0.5 foot below the top elevation of the structures (22 feet msl). The maximum elevation of runup at the Fairhaven Dike is 18.5 feet msl (12.5 feet msl plus 6.0 feet), or 1.5 feet below the design elevation for the top of this structure. In the event of the rare design hurricane, overtopping is of relatively minor consequence at the Main Harbor Barrier because of the large storage capacity in the harbor area. The volume of water overtopping the Fairhaven Dike

is also insignificant. Overtopping is of most importance in the Clark Cove area where the storage is limited. An examination of Table B-9 indicates that the top of the wave runup in a design hurricane will range from 0.5 to 6.0 feet above the top of the main barrier and dike, 6.0 to 7.0 feet above the top of protective works in the Clark Cove area, and 0.0 to 2.5 feet above the top of the Fairhaven Dike. Estimates of the overtopping to be anticipated in connection with Plan "F" protective works in New Bedford and Fairhaven, in the event of a design hurricane are summarized in Table 10 on the following page.

B-14. CURRENT VELOCITIES IN NAVIGATION CHANNEL

The width of the gated navigation opening and the cross-sectional area of the conduit together determine the current velocities through the channel opening. Computations of velocities in the navigation opening and in the conduit were based on routing calculations predicated on the storage capacity in the harbor and the formula $Q = CA\sqrt{2gh}$, where "h" equals the difference between the water surface elevations on the ocean and the harbor side of the barrier, and "C" is a coefficient of discharge assumed to equal 0.75. This formula does not evaluate all the variable losses from contraction, expansion, friction, wind, and other indeterminate factors, but it is believed that the adopted coefficient provides reasonable results.

It has been determined by the routing calculations that the following velocities will be obtained in the 150-foot navigation opening (gate sill at -39 feet msl) at the time of a maximum spring tide, assuming that the 252 square-foot gated conduit through the barrier is flowing full.

Tide	Average Peak Velocities	Maximum Velocities at Center (1)
Flood	1.6 knots	2.1 knots
Ebb	1.8 knots	2.3 knots

(1) 1.3 times the average.

Channel velocities under maximum spring-tide conditions are graphically presented on Plate B-8.

Under existing conditions, the maximum current velocities to be expected in the 350-foot wide navigation channel, with a depth of 30 feet at mlw, is 0.3 knot at the time of a spring tide.

TABLE B-10

OVERTOPPING OF PROTECTIVE WORKS - DESIGN HURRICANE

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

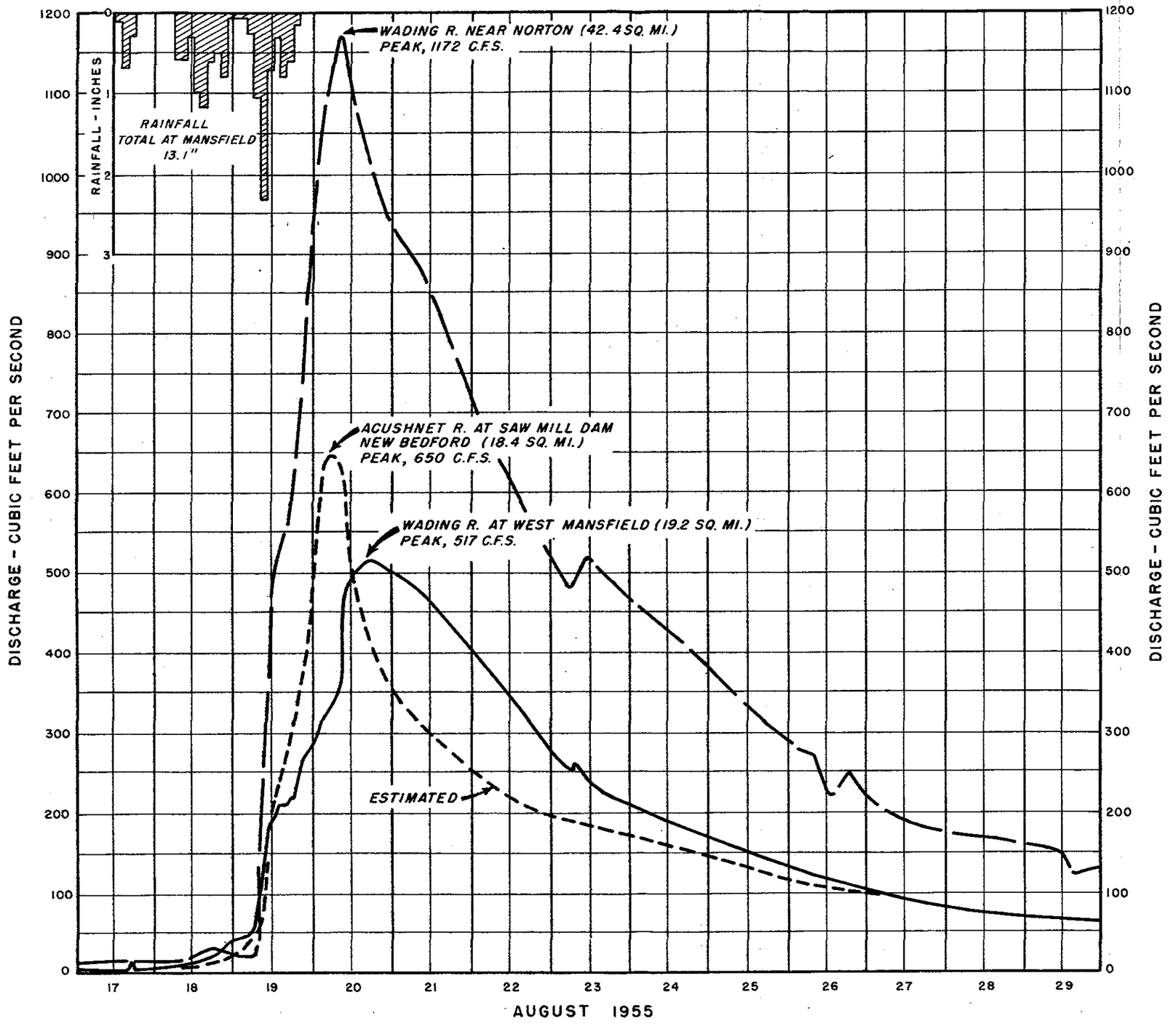
Still Water Level (feet msl)	Hours Prior to Peak	Main Harbor Rate of Overtopping in CFS	Clark Cove Rate of Overtopping in CFS	Fairhaven Rate of Overtopping in CFS
18(1)	0.0	7925	7810	414
16	1.0	3442	3340	159
14	1.3	1232	1252	18
12	1.5	0	0	0
Length of Structure in Feet		7300	5600	3550
Total Vol. of Overtopping in Ac.ft		570	540	29
Area Flooded in Acres		1070	152	18
Average Depth of Flooding in Ft.		0.6	3.6	1.7
Maximum Water Surface in Feet msl(2)		(3)	13.6	6.6

(1) Peak level.
(2) From ponding of water that overtops protective structures.
(3) 0.6 feet above water level at time of gate closing.

The curve shown on Plate B-9 indicates the velocities against which the navigation gates would be required to operate during a recurring September 1938 hurricane and emphasizes the desirability of early closure. The tide graph for the September 1938 hurricane (Plate B-7) was analyzed assuming that the navigation gates and the conduits through the barrier were both open during the storm. An average peak velocity of six knots could occur under severe circumstances. The current velocity can be as low as one knot if closure is made at a time when the water surface is at an elevation of zero feet msl. An example of closing the gates during a hurricane when the water is at a level of 3.2 feet msl, equivalent to a maximum spring tide, is also shown on Plate B-9. The flood-tide velocity under this condition is 3.2 knots.

B-15. GATES CONDUIT SIZE

The cross-sectional area of 252 square feet for the gated conduit through the harbor barrier, west of Palmer Island, was selected after several trial routings were made using a maximum spring tide of 5.6-foot range, assuming that the navigation gates were temporarily closed for maintenance purposes and that conditions of design runoff prevailed while the gates were closed. The maximum velocity through the conduit will be about 14 feet per second under this unusual condition. Increasing the cross-sectional area by approximately 40 percent results in decreasing the velocity by only one foot per second. At times when the navigation gates are closed for maintenance purposes, the conduit opening will permit some tidal flow in and out of the pool behind the barrier. The tidal range in the pool, however, will be reduced about one foot under such circumstances and a delay of about one hour will be experienced in the occurrence of both high and low tides. In addition to providing an emergency outlet for storm water, the conduit will also permit a flow of water along the west side of Palmer Island at times when the navigation gates are open.



HURRICANE SURVEY

NEW BEDFORD-FAIRHAVEN, MASS.

DISCHARGE HYDROGRAPHS

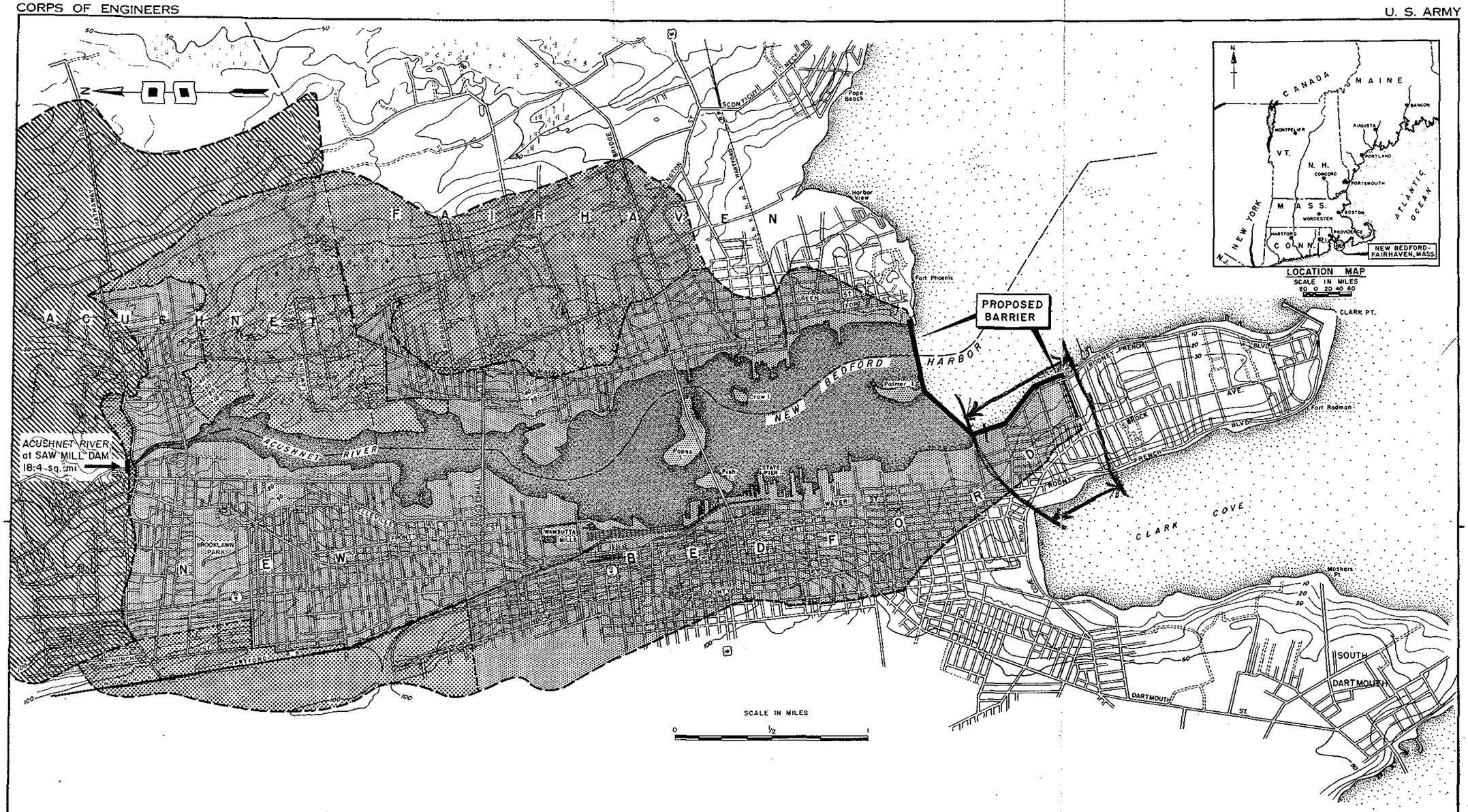
STORM OF 17-20 AUGUST 1955

CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC 1956

PLATE B-1

CORPS OF ENGINEERS

U. S. ARMY



LOCATION MAP
SCALE IN MILES
20 0 20 40 60

LEGEND:

	DRAINAGE AREA SQUARE MILES
ACUSHNET RIVER AT SAW MILL DAM	18.4
SUBURBAN AREA	3.3
URBAN AREA	5.0
HARBOR WATER SURFACE AT M.S.L.	1.7
TOTAL	28.4

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
J. P.	J. P.	J. L. L.

PROJECT ENGINEER
CHIEF, N.E. HURRICANE UNIT
SUPERVISED BY
CHIEF, PLANS & SURVEYS BRANCH
APPROVED
CHIEF ENGINEERING DIV.

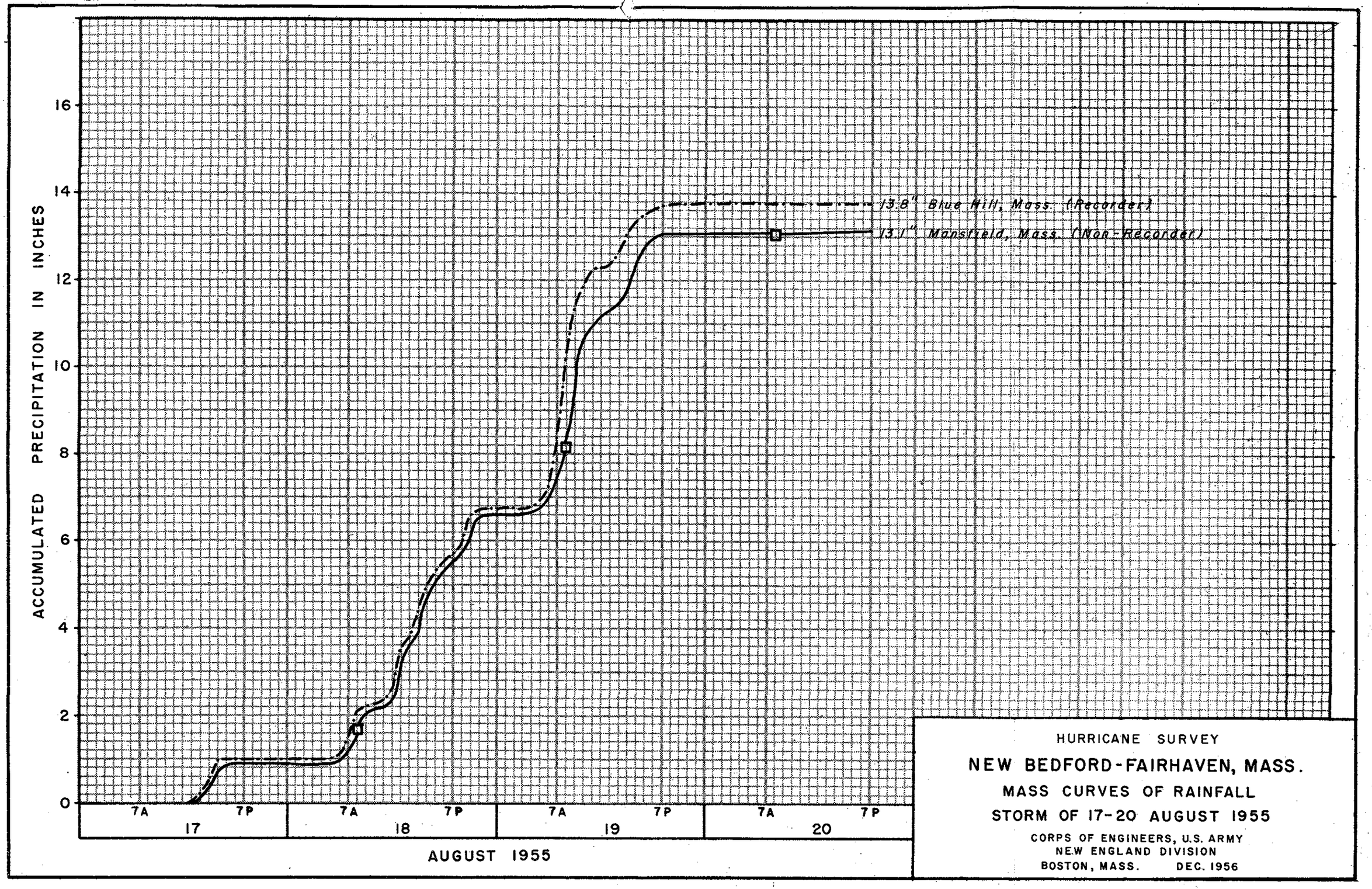
HURRICANE SURVEY
NEW BEDFORD-FAIRHAVEN, MASS.
DRAINAGE AREAS CONTRIBUTING RUN-OFF TO NEW BEDFORD HARBOR

APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER
DATE FEB. 1957

TO ACCOMPANY REPORT DATED 8 FEB. 1957

SCALE AS SHOWN
DRAWING NUMBER
NBFA-3-1000
SHEET 1 OF 1

PLATE B-2



HURRICANE SURVEY

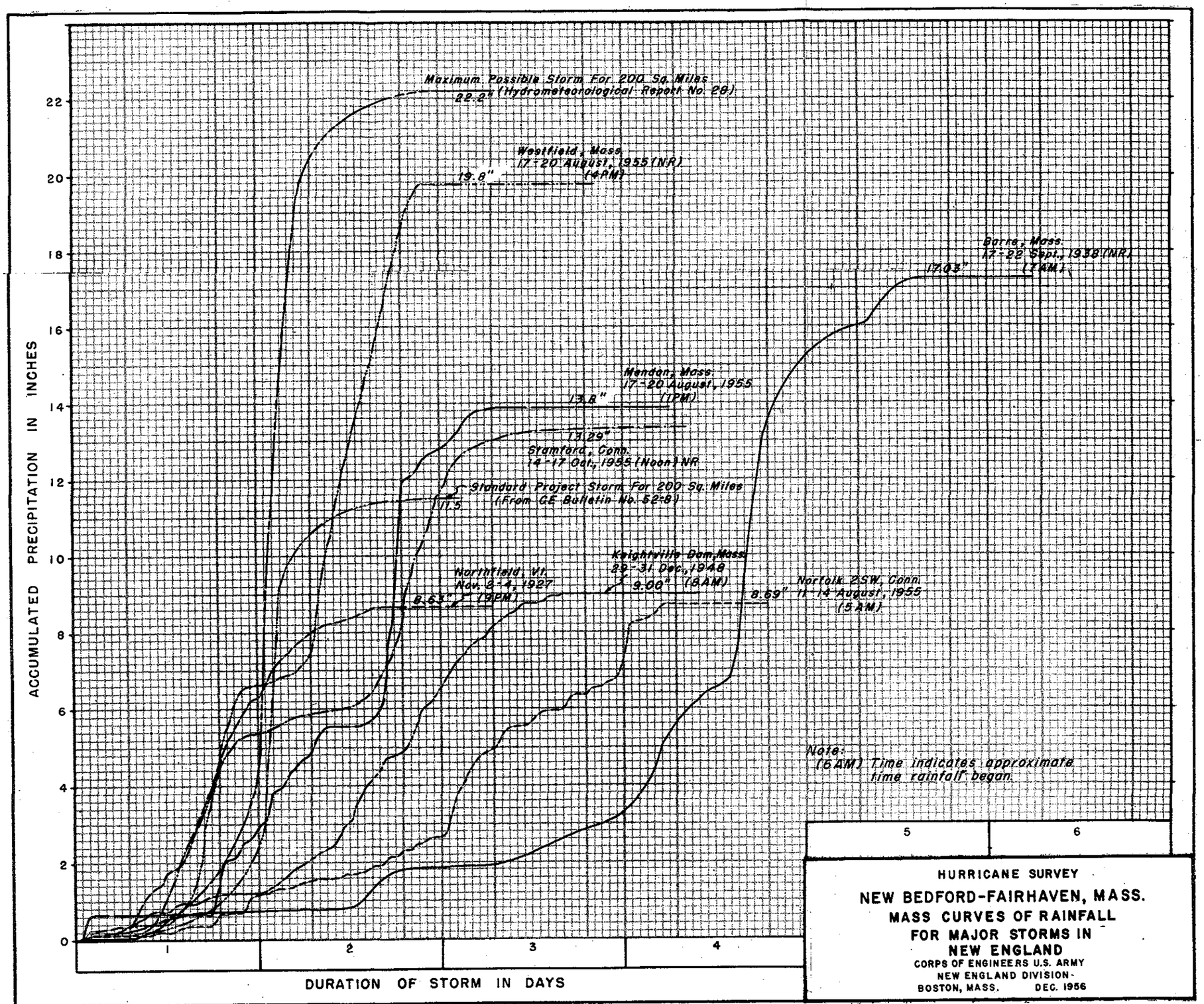
NEW BEDFORD-FAIRHAVEN, MASS.

MASS CURVES OF RAINFALL

STORM OF 17-20 AUGUST 1955

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956

PLATE B-3

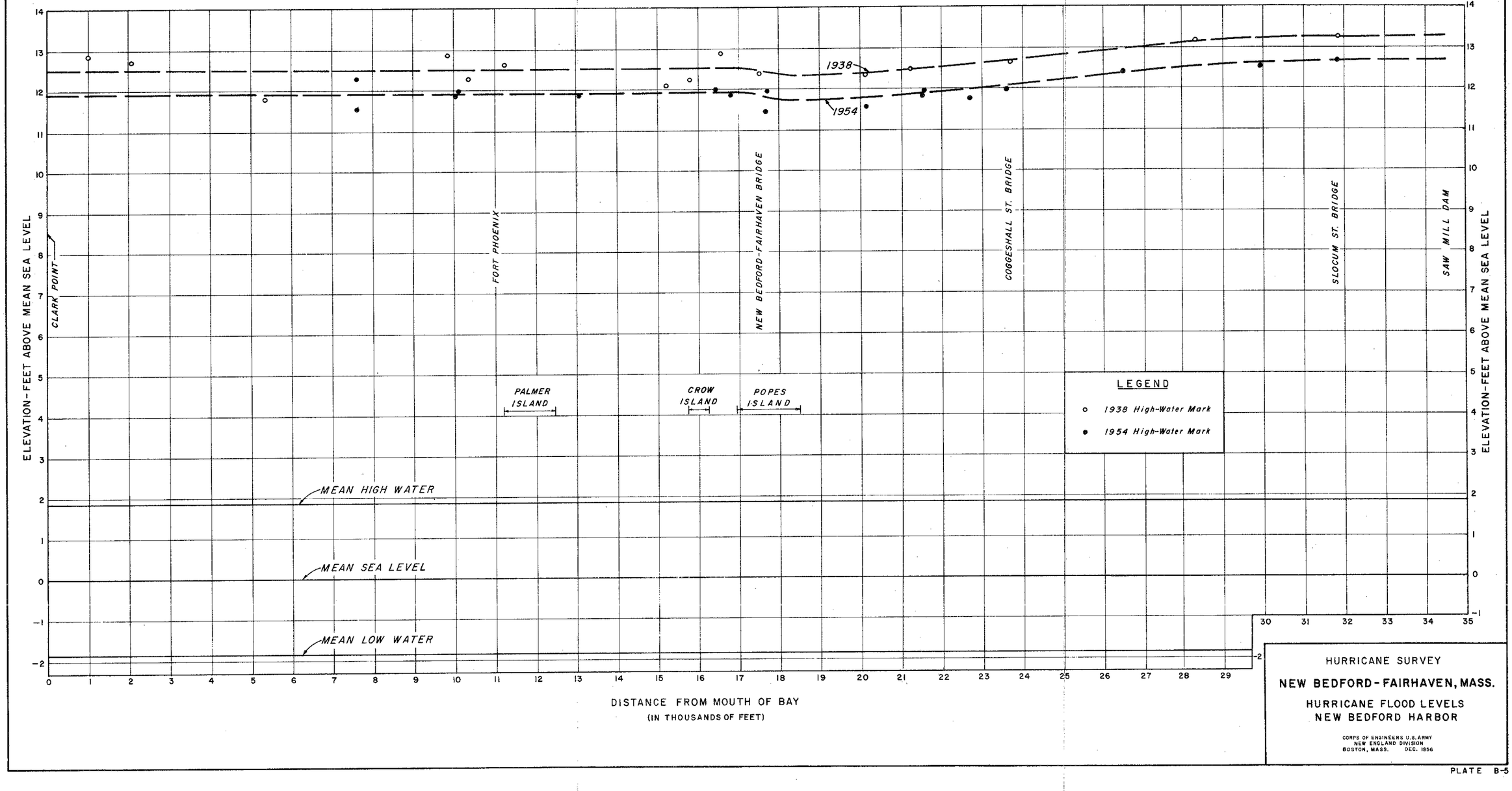


HURRICANE SURVEY

NEW BEDFORD-FAIRHAVEN, MASS.
MASS CURVES OF RAINFALL FOR MAJOR STORMS IN NEW ENGLAND

CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION-
BOSTON, MASS. DEC. 1956

PLATE B-4



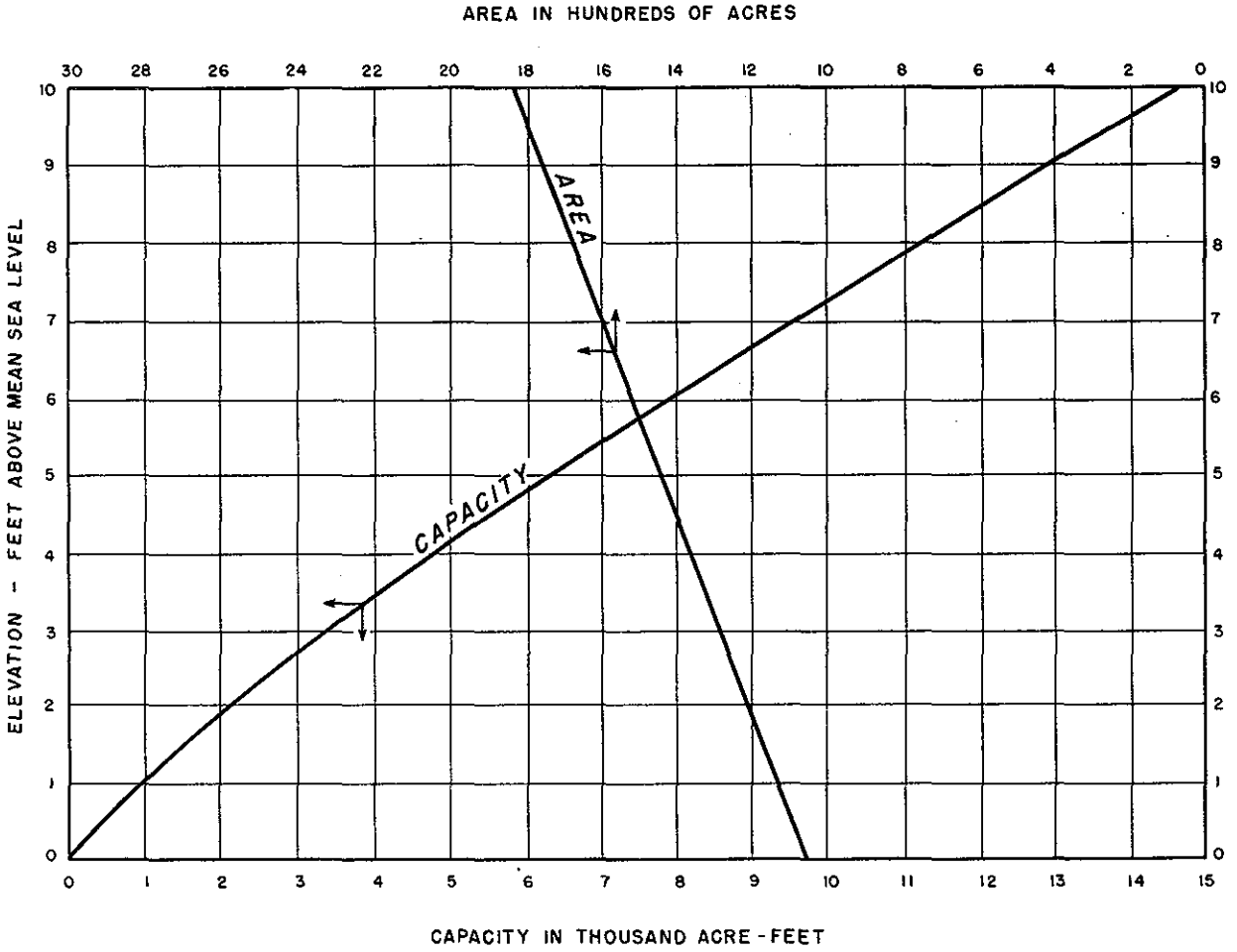
HURRICANE SURVEY

NEW BEDFORD - FAIRHAVEN, MASS.

HURRICANE FLOOD LEVELS NEW BEDFORD HARBOR

CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956

PLATE B-5



NOTE

BASED ON USGS MAPS

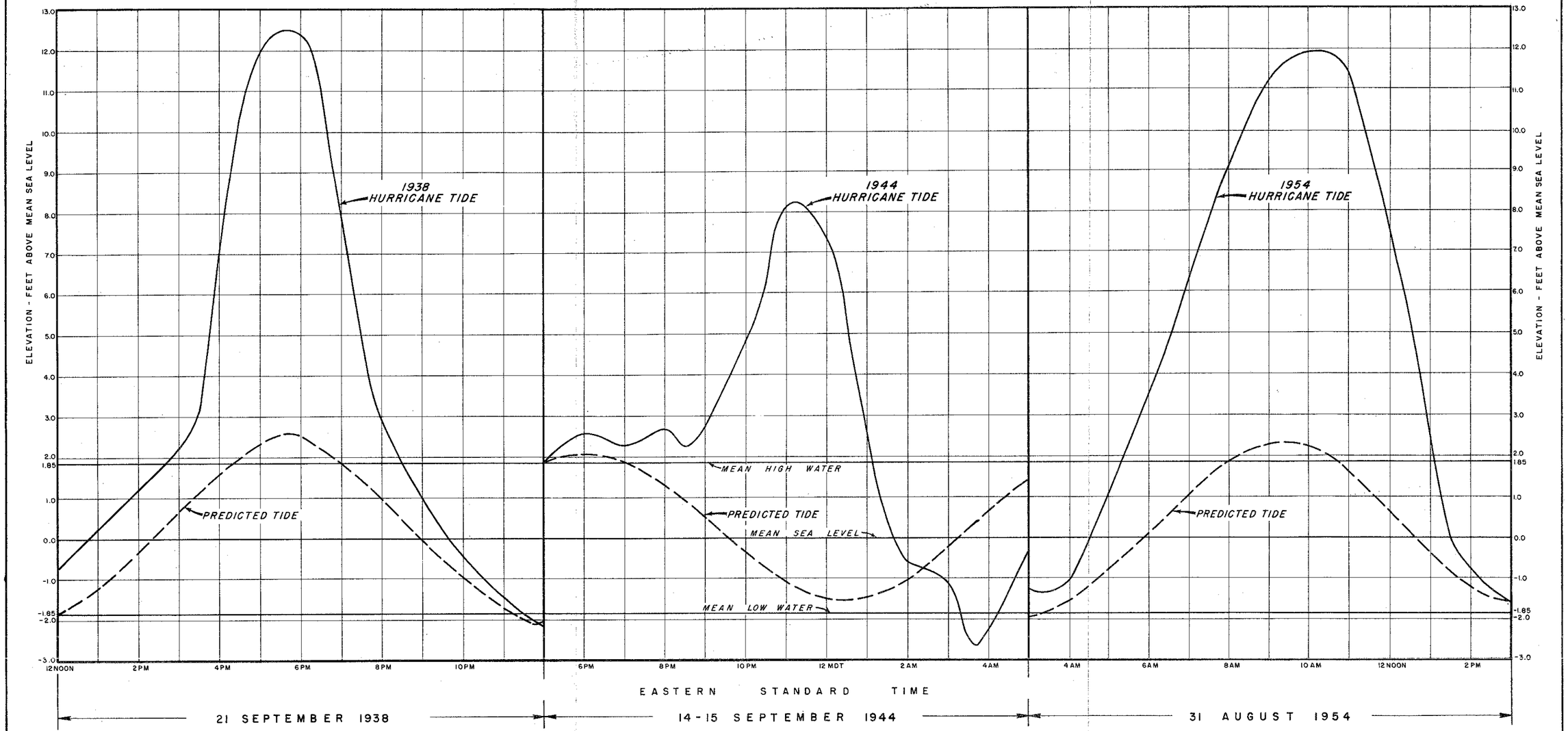
HURRICANE SURVEY

NEW BEDFORD - FAIRHAVEN, MASS.

AREA AND CAPACITY CURVES
NEW BEDFORD HARBOR, PLAN "F"

CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC 1956

PLATE B-6



NOTE:
1938-Hurricane tide curve based on reported heights.

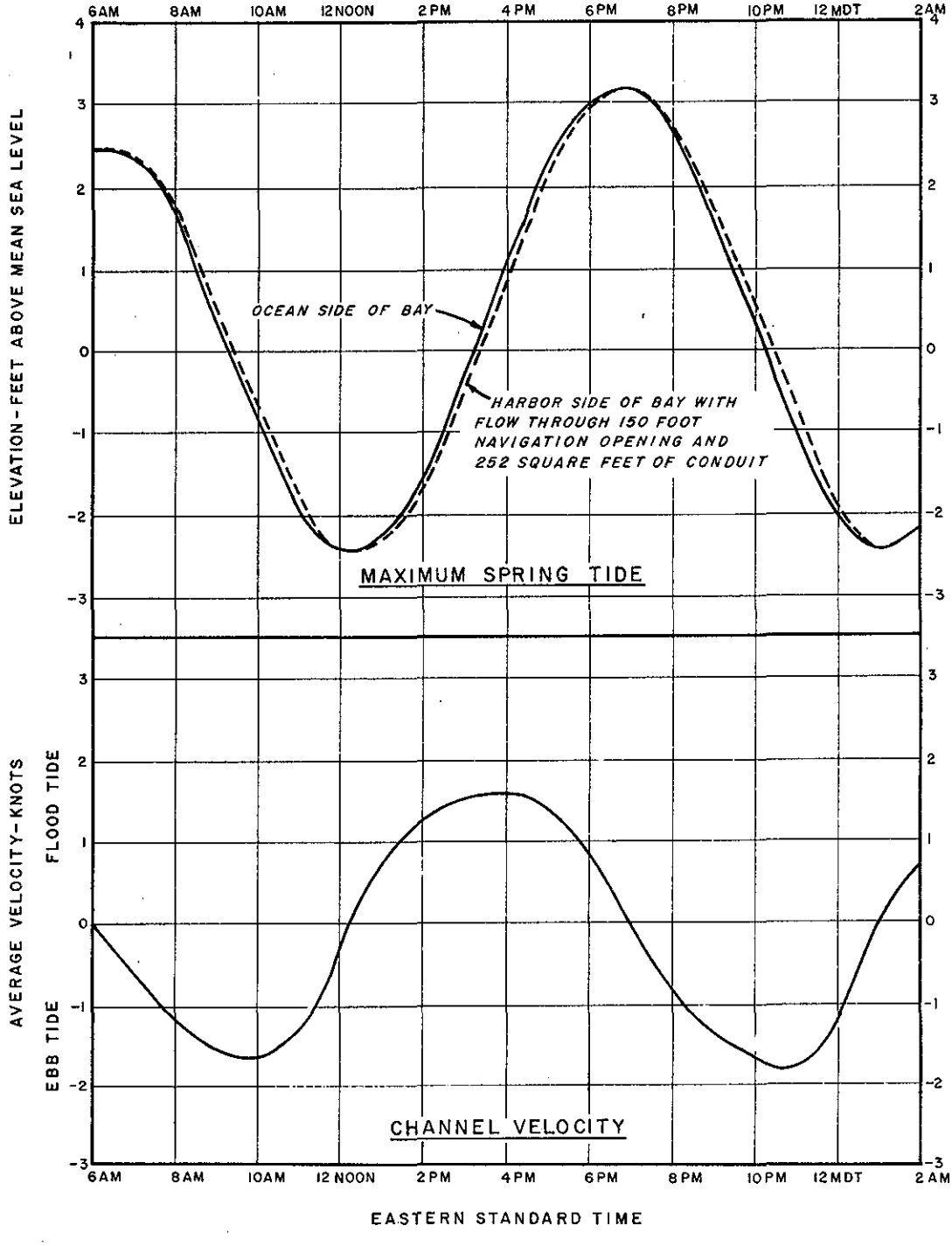
NOTE:
1944-Hurricane tide curve based on recording gage at New Bedford, City Eng. Dept. Drawing, File No. 5842

NOTE:
1954-Hurricane tide curve based on U.S.C.&G.S. recording gage at Newport, R.I.; New Bedford recording gage destroyed in this hurricane.

HURRICANE SURVEY
NEW BEDFORD-FAIRHAVEN, MASS.
TIDE CURVES
HURRICANES OF 1938, 1944 & 1954

CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956

PLATE B-7



NOTES

1. Gate Sill at Elevation -39.0 Feet MSL
2. Determinations based on predicted spring tide for 5 August 1956

HURRICANE SURVEY

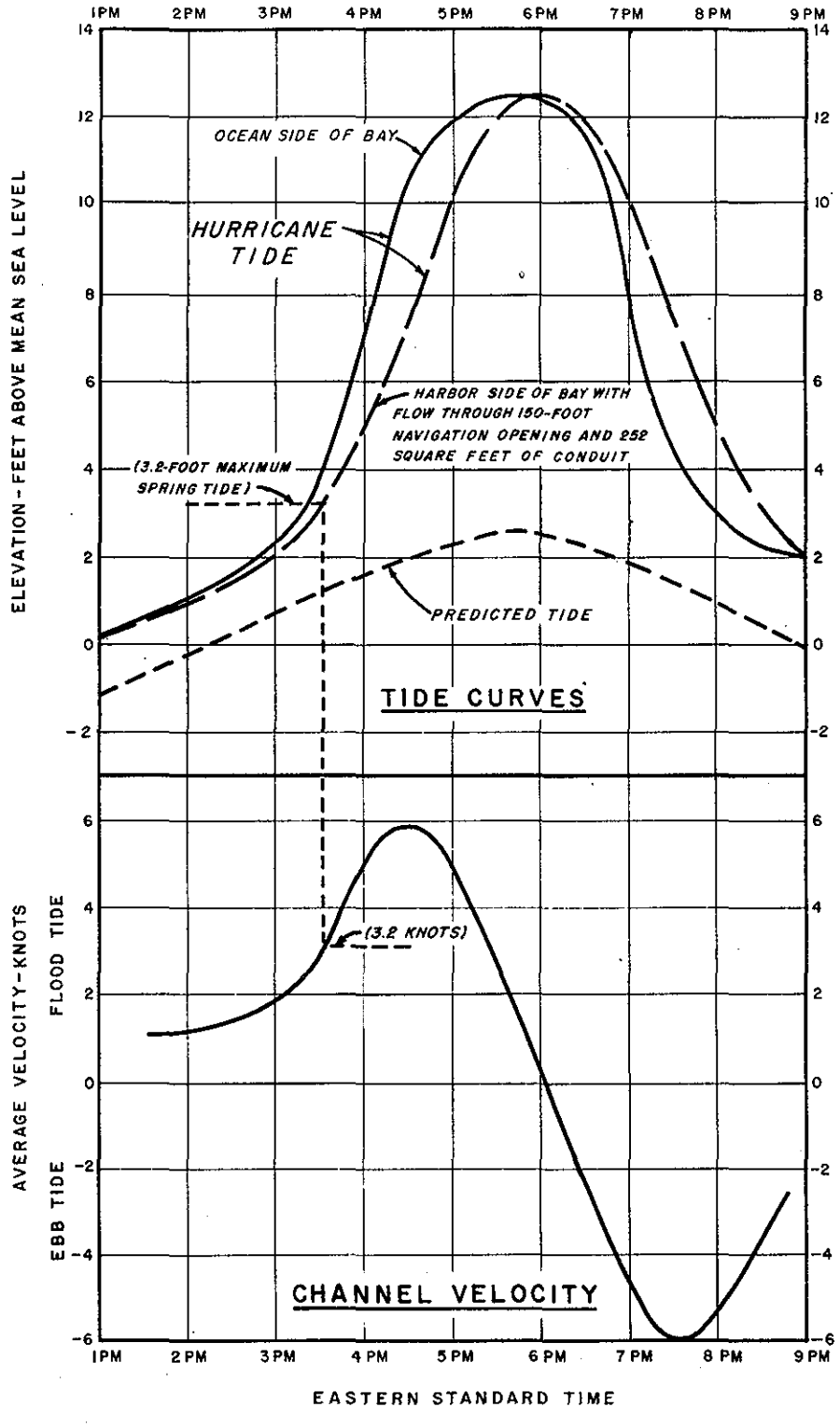
NEW BEDFORD-FAIRHAVEN, MASS.

PLAN "F"

NAVIGATION OPENING VELOCITIES WITH MAXIMUM SPRING TIDE

CORPS OF ENGINEERS U.S.ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956

PLATE 8-8



NOTE
Gate Sill at Elevation -39.0 Feet MSL

HURRICANE SURVEY
NEW BEDFORD-FAIRHAVEN, MASS.
PLAN "F"
NAVIGATION OPENING VELOCITIES
HURRICANE OF 21 SEPTEMBER 1938
CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956

PLATE B-9

APPENDIX C

HISTORY OF HURRICANE OCCURRENCES

APPENDIX C

HISTORY OF HURRICANE OCCURRENCES

C-1. GENERAL

A review has been made of historical data on past hurricanes that have struck or threatened the south coast of Massachusetts and Rhode Island in order to determine the possibility of future hurricane occurrences in the New Bedford-Fairhaven area. Since New Bedford and Fairhaven Harbor lies in the path of hurricanes moving into New England from the south, it has frequently borne the brunt of these storms. The records indicate that the harbor area has experienced or has been threatened by hurricane tidal flooding upon 60 occasions from 1635 to date. The greater number of these hurricanes, owing to the locations of their paths, did not cause any tidal flooding in the survey area. However, they did present a potential threat of such flooding. The ten hurricanes which have created the greatest tidal flooding in the New Bedford-Fairhaven area, as far as can be determined from existing records, are listed below in their estimated order of magnitude:

August 1638	December 1878
August 1635	October 1866
September 1938	September 1869
August 1954	October 1878
September 1815	September 1944

Many of the early great hurricanes caused extensive tidal flooding, in some instances, probably the greatest ever experienced in this area during the past 200 to 300 years. However, since the extent of flood damages is relative to the degree of development in the flooded area, these early hurricanes were not as damaging as the great hurricanes of the present century. The two earliest hurricanes of record, which according to historical accounts, must have been very severe, occurred prior to the settlement of New Bedford. The recurrence of these two hurricanes under present conditions would cause extensive damages, possibly in excess of the damages suffered in 1938 and 1954.

C-2. SUMMARY OF HURRICANE OCCURRENCES

A summary has been prepared (see Table C-1), which lists all hurricanes known to have directly affected the New Bedford-Fairhaven area, and, also, all hurricanes known to have threatened

the area. In the latter case, a slight change in meteorological conditions could have caused any of these hurricanes to follow a course over the area under study, thereby subjecting the area to tidal flooding. In several instances, where there are early records of a great storm striking the coast of Massachusetts and Rhode Island, it has been assumed that the storm affected the New Bedford area. The following classifications indicate the effect of the recorded hurricane occurrences on the survey area:

Type "A": Hurricanes causing tidal flooding.

Type "B": Hurricanes causing damage from wind and rainfall; no evidence of tidal flooding.

Type "C": Hurricanes threatening the area; no damage.

Of the 60 hurricanes of record that either hit or narrowly missed striking the New Bedford-Fairhaven area, as listed in Table C-1, 12 are of type "A", 13 of type "B", and the remaining 35 of type "C". Thirty-six of the listed hurricane experiences (3 type "A", 7 type "B", and 26 type "C") have occurred during the period from 1901-1955. The fact that there is a record of 36 hurricanes in this 55-year period, as compared with 24 in the 266-year period from 1635-1900, is not considered indicative of a greater trend in hurricane activity in recent years, but to a lack of records and information on storms prior to 1900.

TABLE C-1

HISTORICAL HURRICANES

New Bedford-Fairhaven Area, Massachusetts

Date of Hurricane	Category (1)	Source of Data	Remarks
1635, Aug.15	A	(2)(3)	Great tidal surge; height of tidal flooding probably exceeded that of Sept.1938.
1638, Aug.3	A	(3)	Historical account indicates greatest tidal flooding ever experienced along Mass. and R. I. coast.
1723, Oct.30	A	(3)	Very high tides in R. I.; considerable damage.
1757 -	C	(2)	Atlantic Coast hurricane, Florida to Boston, Mass.
1761, Oct.24	A	(3)	Very high tides in Narragansett Bay, R. I.; reports of much damage from wind and water.
1770, Oct.19-20	B	(3)	A violent storm; immense loss of life and property along the coast.
1773, Aug.	C	(2)	Passed near Boston, Mass. No record of damage at New Bedford.
1788, Aug.	C	(2)	Affected western New England; much damage in Conn. and Mass.
1804, Sep.3-9	C	(2)	Severe storm; passed over Cape Cod, travelling northeast.

(Footnotes are at end of table.)

TABLE C-1 (Cont'd)

Date of Hurricane	Category[1]	Source of Data	Remarks
1804, Oct.9-10	C	(2)(3)	Reported wind damage; no other material damage.
1815, Sep.18-24	A	(2)(3)	Tide rose a reported 10 feet above high water on the 23rd.
1821, Sep.1-4	B	(2)(3)	Wind damage; no unusual rise in tide. Intensity of storm hit New York.
1829, July 24	C	(2)	Reported to have been felt in Boston, Mass.; no accounts of damage in New Bedford.
1841, Oct.3-6	B	(2)(3)	Wind damage. Path was probably near Nantucket.
1854, Sep.6-14	C	(2)	Severe in southern states; passed over New England, near Boston.
1866, Oct.29,30	A	(2)(3)	Unusually high tide; submerged several wharves.
1869, Sep.8	A	(2)(3)	Tide rose to level of wharves, much damage.
1877, Sep.21 - Oct.5	B	(2)(3)	Wind and rain damage. Path was south of Long Island and Nantucket.
1878, Oct.18-24	A	(2)(3)	Some wharves flooded; heavy rain. Destructive storm along the coast.
1878, Dec.10	A	(3)	Wharves covered by tide; gale winds.
1879, Aug.16-20	C	(2)	Path followed up coast, passed over Cape Cod. No account of damage.

TABLE C-1 (Cont'd)

Date of Hurricane	Category[1]	Source of Data	Remarks
1889, Sep.1-13	C	(2)(3)	Accounts of high tides and waves at Newport, R. I.
1893, Aug.13-26	B	(2)(3)	Track was west of New York. Wind damage in New Bedford.
1896, Sep.3-11	B	(2)(3)	Strong winds; local flooding from rainfall.
1901, Sep.9-19	C	(2)(4)	Passed south and east of Cape Cod, travelling northeast.
1902, June 11-20	C	(2)(4)	Path crossed Buzzards Bay and Cape Cod, moving northeast; no accounts of damage.
1902, June 19 July 1	C	(2)	Center passed over Conn. and southern R. I., travelling southeast; no accounts of damage.
1902, Oct.7-13	C	(2)(4)	Along path south of Long Island and Nantucket, moving east.
1903, Sep.13-17	C	(2)(3)	Storm crossed northeastern Pa., moving northwest. No local damage recorded.
1904, Sep.8-16	B	(2)(3)	Center passed over northeastern Conn., moving northeast. Local wind damage.
1904, Nov.9-14	C	(2)(4)	Passed south of Nantucket, moving northeast.

TABLE C-1 (Cont'd)

Date of Hurricane	Category[1]	Source of Data	Remarks
1911, Aug.29-30	C	(2)	Passed south of New Bedford and Cape Cod; no accounts of local damage.
1912, Sep.11-23	C	(2)	Passed near New Bedford; followed easterly path across southern New England.
1916, July 12-22	C	(2)(4)	Passed over Providence, R. I. and south of Boston, Mass., heading northeast. No accounts of damage.
1920, Sep.27 - Oct.1	C	(2)(4)	Storm passed just west of New York, heading north.
1923, Oct.14-19	C	(2)(4)	Passed near Boston, moving northwest. Storm of slight energy.
1924, Aug.16-27	B	(2)(3)	Crossed east tip of Cape Cod, moving northeast. Some damage from strong winds and heavy rain.
1929, Sep.22 - Oct.4	C	(2)(4)	Moved northeast, passing over eastern New York state and northwestern Vermont.
1933, Sep.10-16	B	(2)(3)	Passed south of Cape Cod, moving northeast; heavy seas and rain.
1934, Jun.4-21	C	(2)	Travelled overland from Louisiana; crossed Long Island and Cape Cod, moving northeast.

TABLE C-1 (Cont'd)

Date of Hurricane	Category(1)	Source of Data	Remarks
1934, Sep.5-9	C	(2)(4)	Crossed Long Island and central Conn., moving north.
1936, Sep.8-26	B	(2)(3)	Passed south of Nantucket, heading northeast; high seas; wind and rain damage.
1938, Sep.16-22	A	(2)(3)(4)	Most damaging storm to strike southern New England. Ten-foot surge, on top of spring tide, caused flooding to 12.5 ft. m.s.l., 10.7 ft. above m.h.w.
1940, Aug.30 - Sep.3	B	(2)(3)	Passed south of Nantucket, heading northeast; strong winds caused minor damage.
1940, Sep.11-18	C	(2)(4)	Followed northeasterly path east of Cape Cod.
1943, Oct.11-17	C	(2)(4)	Passed east of Cape Cod, moving due north.
1944, Jul.31 - Aug.4	C	(2)(4)	Moved northeasterly along path south of Long Island and Nantucket.
1944, Sep.9-15	A	(2)(3)	Center passed over Providence, R. I. and south of Boston, Mass. Surge 9.5 ft., hitting at low tide, caused flooding to 8.2 ft., m.s.l.
1944, Oct.13-21	C	(2)(4)	Path crossed over Nantucket and easterly tip of Cape Cod.

TABLE C-1 (Cont'd)

Date of Hurricane	Category[1]	Source of Data	Remarks
1945, June 20-27	C	(2)(4)	Followed northeasterly path from Florida to Nova Scotia, passing south of Nantucket.
1945, Sep. 12-19	C	(2)	Overland from Florida; passed just west of New York, moving northeast.
1949, Aug. 24-29	C	(2)(4)	Travelled overland from northern Florida, crossed center of Maine.
1950, Aug. 11-21	C	(2)(4)	Passed south of Nantucket, heading generally northeast; strong winds at Cape Cod. No reports of local damage.
1950, Aug. 31 - Sep. 14	B	(2)(3)	Passed south and east of Nantucket, then headed east. Reports of minor damage from wind and seas.
1952, Aug. 25 - Sep. 1 ("Able")	C	(2)	Followed northeasterly track, approximately over New York.
1953, Aug. 11-15 ("Barbara")	C	(2)(4)	Followed path south of Long Island and Nantucket.
1953, Aug. 29 - Sep. 8 ("Carol")	C	(2)	Passed east of Cape Cod heading generally north.

TABIE C-1 (Cont'd)

Date of Hurricane	Category	Source of Data	Remarks
1954, Aug. 25-31 ("Carol")	A	(2)(3) (4)	Second most damaging storm to hit New Bedford. Crossed east end of Long Island, moving north. Surge of nearly 10 ft. during a spring tide caused flooding to 11.9 ft., msl.
1954, Sep. 6-11	B	(2)(3)	Passed over Cape Cod, heading northeast. High seas, minor damage from wind.
1955, Aug. 10-19 ("Diane")	C	(2)(3)	Passed just south of Long Island and about over Nantucket. Brought record rainfall to many areas of New England. No reports of local damage at New Bedford.

Notes

(1) The following assigned categories pertain to the effect of a hurricane on the New Bedford-Fairhaven area, Mass.
A: Caused tidal flooding.
B: Caused damage from wind or rainfall.
C: Threatened area; no damage.

(2) "Hurricanes - Their Nature and History," by I.R. Tannehill (1956).

(3) Local newspaper accounts, histories, etc.

(4) Material furnished by U. S. Weather Bureau.

C-3. DESCRIPTIONS

Brief descriptions of type "A" and type "B" hurricanes experienced in the New Bedford-Fairhaven area, as recorded by historians and as reported in newspaper accounts and other records, are given below.

a. 15 August 1635. From: "Of Plymouth Plantation, 1620-1647," by William Bradford.

> "This year the 14 or 15 of August (being Saturday) was such a mighty storm of wind and rain, as none living in these parts either English or Indian, ever saw, being like (for the time it continued) to those Hauricanes and Tuffons that writers make mention of in the Indies. It began in the morning, a little before day, and grew not by degrees, but came with violence in the beginning to the great amazement of many. It blew down sundry (211) houses, and uncovered others; divers vessels were lost at sea, and many more in danger. It caused the sea to swell (to the southward of this place) above 20 feet, right up and down, and made many of the Indians to climb into trees for their safety; it took off the board roof of a house which belonged to this plantation at Manamet, and floated it to a other place, the posts still standing in the ground; and it if had continued long without the shifting of the wind, it is like it would have drowned some part of the country. It blew down many hundred thousands of trees, turning up the stronger by the roots, and breaking the higher pine trees off in the middle, and the tall young oaks and walnut trees of good bigness were wound like a withe, very strange and fearful to behold. It began in the southeast and parted toward the south and east, and veered sundry ways; but the greatest force of it here was from the former quarters. It continued not (in the extreme) above 5 or 6 hours, but the violence began to abate. The signs and marks of it will remain this 100 years in these parts where it was sorest. The moon suffered a great eclipse in the second night after it."

From: "The History of New England from 1630 to 1649," by John Winthrop.

> "...This tempest was not so far as Cape Sable, but to the south more violent, and made a double tide all that coast...
>
> "The tide rose at Narragansett fourteen feet higher than ordinary and drowned 8 Indians flying from their wigwams."

b. 3 August 1638. From: "The History of New England from 1630 to 1649," by John Winthrop.

> "In the night was a very great tempest or hiracano at S.W. which drave a ship on ground at Charlestown, and brake down the windmill there, and did much other damage. It flowed twice in 6 hours and about Narragansett it raised the tide 14 or 15 feet above the ordinary spring tides upright."

c. 30 October 1723. From: "The Boston News-Letter, No. 1033. From Thursday November 27. to Thursday November 14. 1723."

> "Rhode Island, November 1 ...
> " ... On Wednesday last we had here a very great South East storm of Wind & Rain, and a very high Tide, a Foot higher than ever was known before, which has broken & carried away several of our Wharffs, and drove some vessels ashore from their anchors and was done considerable damage in Warehouses and Cellars, to dry goods, and other merchandize: the Loss is computed to some thousand pounds..."

d. 24 October 1761. From: "The Boston News-Letter No. 2991. Thursday, October 29, 1761."

> "Last Friday evening between 8 and 9 o'clock came on the severest N.E. Storm of Wind and Rain that has been known here for 30 Years past, and continued "till between 2 and three o'Clock next Morning;...Five or six Vessels were drove ashore at Providence in Rhode Island Government, and greatly damag'd, and it being high Water there it got into the Stores and Cellars and damag'd Sugars &c. to the amount of 12 or 15,000 (pounds) their Currency; it has also entirely carried away the great Bridge at that Place. - On both roads East & West, so far as we have heard, the Roofs of Houses, Tops of Barns, and Fences, have been blown down, and it is said Thousands of trees have been torn up by the Roots by the violence of the above storm, and we fear we shall hear melancholy Accounts of Damage done at Sea."

From: "The Newport Mercury."

"on Friday last came on a terrible storm from the Northeast, which continued increasing with a very heavy rain, and did not abate till after 2 in the morning. The violence of the wind broke off part of the steeple of Trinity Church. Several persons sustained considerable loss in their sugar, salt, etc. by the prodigious rise of tide, which flowed into their stores and cellars. Many of the ships in the harbor were driven ashore from the wharves and their moorings, but without any considerable damage except to two ships. Sad havoc has been made with the lumber and wood on the wharves, great quantities of fence blown down and numbers of trees torn up by the roots. People hardly thought themselves safe in their own houses, for a more violent storm has scarce ever been known here."

e. 19-20 October 1770. From: "History of the State of Rhode Island," by Samuel Greene Arnold.

" A violent storm again blew down a part of the spire of Trinity Church at Newport, and caused an immense loss of life and property along the coast. Newport suffered very severely in this gale."

f. 18-24 September 1815. From: History of New Bedford and Its Vicinity," by Leonard Bolles Ellis.

"On Saturday morning, September 29 (sic) (23) 1815, New Bedford was visited by a tremendous gale, that for violence and disaster has never been equaled. in the history of the town. The gale began early in the day and continued with great violence till midday. The tide rose 10 feet above high water mark, and 4 feet higher than ever was reached before. So rapid was its rise that the occupants of stores and warehouses along the river front were compelled to leave them hurriedly.

"Salt works carried away, shops wholly or partially destroyed, several dwelling houses were blown down, all the wharves were injured and some of them ruined; 16 vessels were blown adrift and thrown ashore."

g. 1-4 September 1821. From: "The Newport Mercury."

"During the severe gale on Monday night, the Brig Commerce got loose from her fastening at one of the wharves near the Market, and came with a tremendous crash against the bridge, slightly injuring some small craft which lay in her course, and the railing of the bridge. Considerable damage was done to trees, etc. in this vicinity by the gale; a part of Butts Rope Walk West Side, and an unfinished building at the North end, were blown down; the tower erected for the accomodation of the wild beasts (our annual commencement visitors) in the yard of Wessons Hotel, was also demolished but its inmates were secured from elopement.

"Much apprehension was entertained for several hours of disasters by flood as well as wind, and there were many waking eyes and throbbing hearts; but happily the tide and the residents within the range of the devastations by the never-to-be-forgotten flood of 1815 retired to their beds about midnight, providently delivered from a visitation fearfully anticipated, and dreaded equally with fire brands, arrows and death. The tide did not rise much above its usual bounds."

h. 3-6 October 1841. From: "Daily Mercury," New Bedford.

"A severe northeasterly storm commenced here on Saturday night and continued on Sunday and yesterday with but a little abatement. Some damage was done to the shipping and many chimneys were blown down. A large unfinished stone building was blown entirely down, and one or two small houses destroyed."

i. 29-30 October 1866. From: "Daily Mercury," New Bedford.

"The southeasterly which commenced on Monday morning and was accompanied during the night by rain blew a gale yesterday forenoon and the water fell in torrents. The tide was unusually high submerging several wharves and at one time nearly crossing Front Street. Several vessels were driven from their moorings by the gale and the rush of the water. Chimneys, fences, etc. were blown down. Telegraph wires were damaged. Railroad bridges were undermined. About 3:00 p.m. the gale had spent its force."

j. 8 September 1869. From: "History of New Bedford and Its Vicinity," by Leonard Bolles Ellis.

> "On the 8th of September 1869, a destructive southeast gale swept over the city and vicinity. It began about 4:00 in the afternoon, increasing rapidly in force, and continued until about 7:00 p.m. The tide rose to the level of the wharves, and huge waves swept over them. Buildings were unroofed, fences blown down, trees uprooted, chimneys blown down; vessels strewn on both sides of the river, all more or less damaged and some dismasted. A costly result of the gale was the destruction of the New Bedford and Fairhaven bridge."

k. 21 September to 5 October 1877. From: "New Bedford Evening Standard."

> "A severe storm of wind and rain commenced last night and continued through the night and day. Some of the rain came in sheets and the layers of sand which have washed down upon the lower streets attests the amount of rainfall.
>
> "Limbs were broken off, fences blown down, walnuts and fruits blown from trees.
>
> "More water than the drains could carry off ran from the Second Street gutter into the Robeson Building. Sycamore Street, between County and Summer, is badly gullied,the gutter having been obstructed by a private bridge which turned the current into the middle of the street.
>
> "The damage along the water front is insignificant as ample notice was given by old indications and preparations made for the storm. Several vessels in the harbor dragged their anchor. On the north side of Fish Island some spars and a scow got loose.
>
> "Capt. Joseph C. Delano's gauge indicated a rainfall of 3.2 inches."

l. 18-24 October 1878. From: "New Bedford Evening Standard."

> "The storm yesterday afternoon and last night was very severe, the rain falling in torrents, but there was very little damage in this vicinity. Several vessels and boats got adrift at the docks, but trifling damage

was done, some of the wharves were flooded. The last train from Providence was prevented from reaching Fall River on account of a washout near Cole's River. The velocity of the wind was 50 miles an hour. The storm originated in the Gulf of Mexico on Monday morning."

m. 10 December 1878. From: "New Bedford Evening Standard."

"The southeast storm of yesterday and last night was very severe, the rain falling copiously and the wind blowing a gale. The wharves were covered by the tide at 8:00 p.m. which was higher than since the great September gale of 1869. The rainfall in this city during the storm of Monday and yesterday (including the melted snow) was 1.56 inches."

n. 13-26 August 1893. From: "New Bedford Evening Standard."

"Early last evening a shower fell in this city, and this was succeeded by a second one about 11:30 p.m. About 1:45 a.m. the wind began to rise and came from the southeast, reaching the force of a moderate gale, and at 6:00 a.m. had attained a velocity of 23 m.p.m. The wind at times came in gusts, lasting perhaps two minutes, when the velocity would reach 40 m.p.h. Rain accompanied the wind, falling heavily for several hours. Trees were blown down, chimneys blown over, trolley wires broken, etc. No serious damage was done to any vessels although they were tossed about. Water was blowing over the New Bedford and Fairhaven railroad."

o. 3-11 September 1896. From: "New Bedford Evening Standard."

"A storm began in this city between Tuesday night and Wednesday morning. All through Wednesday there were frequent heavy showers. During the afternoon the wind which all the time was from the northeast, increased to hurricane force and the weather bureau hoisted signals at this port giving warnings. The greatest force of the wind in this city was 45 miles an hour reached at 8:00 this morning, but the force has decreased considerably since. There is a peculiarity in regard to this hurricane in that it seems to have been confined on the land to a comparatively

limited area, which would indicate that the hurricane had much of its force at sea and struck the coast at the east of New York City, passed over a tract of territory to the south of Boston and went off to sea again. In this city and vicinity the wind was heavy during the night and there was a continual downpour of rain, which kept up almost unceasingly this forenoon. The low lying region on South Water Street, between Howland and Grinell Streets, presented the usual flooded appearance which follows all heavy storms. The depth of water at some points was over two feet and stores on the line in many cases had to be closed. No serious damage to boats. Extra moorings put out. Three or four craft came ashore but were hauled up high and dry. Planking ripped off landing stage at fish wharf near Middle Street. The rainfall as registered at the water works pump house up to 11:00 a.m. today was 3.64 inches. The easterly blow raised sad havoc among the little pleasure craft anchored around Bare Kneed rocks at Nonquitt."

p. 8-16 September 1904. From: "The Morning Mercury," New Bedford.

"Yesterday's storm will probably pass as the September gale. The wind was recorded as blowing 40 miles an hour but it was of a cyclonic nature that twisted things badly. The wind blew from the southward until 8:00 when it whipped around and came out from the northwest and blew hard. The storm raged at its worst at about 6:30 and then the small yachts at anchor in the harbor suffered. A few vessels broke loose and suffered damage. Above the bridge, however, the wind and sea worked havoc with the small boats of the Apponegansett Boat Club. Nearly all of them broke from their moorings; some sunk, others damaged. The tide at Padanaram acted queerly and rose and fell three times during the day. The damage about the city to trees and buildings was considerable. Telephone and telegraph service was out of working order. The tide played queer tricks. At Merrill's wharf it was said that the tide dropped 8 inches in 5 minutes. The maximum velocity attained by the wind was 40 miles an hour."

q. 16-17 August 1924. From: "New Bedford Evening Standard."

"For nearly an hour yesterday the wind swept New Bedford streets at 60 miles an hour, the heaviest velocity on record since the gale of 1869. The high velocity began about 3:30 p.m. Before this the gale had been blowing at more than 30 miles an hour. The lowest point which the barometer reached was 29.05 according to the records at the City Engineer Office. At the Old Dartmouth Historical Society the barometer went slightly below 29 according to the Assistant Curator. During the gale of 1869 the barometer stood at 29.02. The total rainfall went well above the five and a half inch mark being officially recorded at 5.52 inches. This is the heaviest rainfall on record here. The only storm at which yesterday's storm can be compared is the 1869 gale, according to the City Engineer.

"As the rain decreased in volume this afternoon, the wind gained in velocity ripping up trees by the roots and tearing away whatever was in its path and not firmly anchored; blew over one house.

"New Bedford waterfront suffered comparatively little damage in the storm due to the fact that the wind at its height blew down the river rather than on shore."

r. 10-16 September 1933. From: "Standard Times," New Bedford.

"The storm which began Thursday at 8:30 a.m. brought the heaviest continual rainfall in history of records of the City Engineer Department. A total of 8.57 inches of rain fell from Thursday morning until 7:30 last night. Heaviest of the rain came between 4:00 p.m. Saturday and 4:00 p.m. Sunday when 4.12 inches fell.

"Many cellars were reported flooded in this city and Fairhaven, but none required help of City Departments to bail out. The waterfront experienced most of the discomfort here.

"Both sides of Clarks Point showed evidence of rain and wind. Scores of small craft were swamped and overturned all along the shore, but larger craft appeared to have weathered the gale. At Nonquitt, several craft were reported swamped and two were later salvaged.

"Buttonwood Park Pond overflowed and left a small lake on Court Street. Autos experienced difficulty in getting through to Brownell Avenue.

"Cottages and boats along the east beach at Horseneck were damaged by a tremendous surf which came with the high tide and a stiff northeast gale. A shift in the wind allayed fears of residents that the tide would wash over the roads.

"Fortunate in missing the brunt of the hurricane that turned seaward after a devastating sweep of the South Atlantic seaboard, this city found its chief damage to be flooded cellars."

s. 8-26 September 1936. From: "Standard Times," New Bedford.

"The tropical storm which began lashing southeast Massachusetts yesterday reached its peak fury in this locality between 4:00 and 5:00 a.m. today. Wind velocity at that hour was estimated at nearby Cuttyhunk as 65 miles an hour. Rain which had been descending in apparently maximum quantity came down in still heavier sheets to establish an all time record.

"Local havoc, though extensive, was not severe as compared with the intensity of the storm and the damage and devastation wrought elsewhere. Damages suffered by New Bedford were falling trees, damaged house, downed electric light poles, plate glass windows blown in, doors blown off, tattered awnings, telephone wires down, etc.

"Cornfields laid low spoke eloquently along the countryside of the violence of the gale. Closed to traffic signs barred flooded areas that yesterday were city street.

"Steamship traffic in and out of New Bedford and Fairhaven remained at a standstill this forenoon because of high wind and seas. Highway traffic crawled cautiously

over roads littered as they have not been for 10 or 12 years by fallen boughs and whole trees uprooted, draped menancingly here and there by fallen wires.

"Travelers from Fairhaven crossed the narrows this morning under a barrage of spray from both north and south Watuppa Ponds, which the storm had whipped into the semblance of a white-capped sea.

"Swamped boats bobbed unhappily at their moorings all along the shore line of East Rodney French Boulevard and Clarks Cove.

"When the storm was at its height, breakers pounded the causeway to Gooseberry Neck at Horseneck Beach, causing considerable damage. As the breakers struck the rocks on each side of the causeway they sent up columns of water 40 feet high that met above the causeway. At times the causeway was not visible. Large holes were made in the causeway pavement by the undermining action of the sea.

"More than 6 inches of rain fell from the start of the storm about 7:00 a.m. yesterday to 11:00 a.m. today. From 4:00 p.m. yesterday to 9:00 a.m. alone, the fall was 4.87 inches."

t. 16-22 September 1938. From: "Standard Times," New Bedford.

"A southeast wind which roared into hurricane proportions about 3:00 p.m. started raking this area about noon yesterday. Then the tide, rising with terrifying swiftness, came sweeping in. Banks of the Acushnet River overflowed. By 6:00 p.m. the worst damage had been done and after 7:00 p.m. receding tides, going down almost as quickly as they had come up, left wide areas of destruction and disorder.

"Damage along the New Bedford and Fairhaven waterfronts runs into hundreds of thousands of dollars. Not a dwelling remained standing on East Rodney French Boulevard. Beaches along Sconticut Neck and Fairhaven were in ruins.

"Between 4 and 5 feet of water flooded the New Bedford Railroad Station at Pearl Street and caused undetermined loss when baggage was destroyed.

"Lower floors of business houses in the section roughtly from the railroad tracks up to Front Street were covered by water. To the south, waters reached the alarming depth of nearly 6 feet. In some places, at the foot of Cannon, Madison, and Walnut Streets, along South Water Street, water completely covered autos which had been parked in the streets.

"The cottages at Hollywood Beach, Mattapoisett, were wrecked. Crescent Beach, Mattapoisett, was wiped out. So was Horse Neck Beach in Westport. Only one stone dwelling remained standing at Westport Harbor. Crescent Beach, Pico Beach and Harbor View were in shambles. An estimate of 170 cottages were lost at Crescent Beach and 15 cottages at the adjoining Pico Beach.

"With exception of one large dwelling all cottages at Potomaka were destroyed. Anthony Beach was swept clean. All buildings at the public bathing beach in Mattapoisett are gone and every boat in the harbor was swept high and dry.

"Hurricane winds reached a velocity of 60 miles an hour at 5:00 p.m. here yesterday, according to official readings on the Municipal Building's anemometer.

"The highest water mark left by the hurricane-driven tide found by the City Engineers today was 13 feet above mean high water opposite the Municipal Bathing Beach. At the head of the Acushnet River the water was 11½ feet above mean high water. It was 10½ feet at the foot of Union Street and 10 feet at Cove Street.

"The chart showed the wind rose from 20 miles an hour at 2:30 p.m. to 50 miles an hour at 3:30 p.m. yesterday. An hour later it was up to 60 miles an hour. The wind was down to 25 miles an hour at 11:00 p.m.

"Estimated property damage in the Greater New Bedford area is $12,500,000, with a death toll of 91."

u. 30 August to 3 September 1940. From "Standard Times," New Bedford.

"Tension among residents of New Bedford, Cape Cod

and the Islands caused by reports of a hurricane heading northward from the Virginia Capes was relieved yesterday after a night of strong wind and accompanying high tides which wrought only comparatively minor damage in this section. The hurricane veered off at Nantucket and headed to sea.

"Although heavy rain fell in the early morning hours and the velocity of the wind was recorded at 40 m.p.h., the weather cleared at an hour when most people were getting up.

"At Cuttyhunk it was reported that while the tide was high it was not above the normal. The barometer there read 27.45 at 6:00 a.m. The Coast Guard reported that shortly after midnight the strong southeast wind which brought threat of the storm shifted to northeast."

v. 9-15 September 1944. From: "Standard Times," New Bedford.

"Greater New Bedford came in for its share of the destruction. The fact that apparently no lives were lost, and only minor casualties occurred, however, helped greatly to temper dismay at the property losses incurred, inconveniences to be endured, and heavy destruction of trees long esteemed as priceless scenic assets of this area.

"Streets of New Bedford, Fairhaven, and other communities throughout this area were a shambles of fallen trees, which blocked virtually every street when the peak midnight fury of wind began to subside. Vigorous young trees as well as patriarchal elms and oaks fell victims to the storm. Many were flung destructively against buildings, ripping up great slabs of paving in their fall.

"Some of the damages reported were plate glass windows blown out, trees uprooted and blown down, telephone lines down, electric lines down, pavements ripped up, flooded dwellings, roofs blown off and in, railroad bridge washed out at Wareham and the 800 foot bridge between Monument Beach and Gray Gables.

"Cottages at Silver Shell Beach on the Sconticut Neck West Shore were swept from their foundations and are for the most part twisted and battered wrecks. All of the cottages had been built since the 1938 hurricane swept the beach clean, and all were fully furnished.

"Water stood 6 inches deep in waterfront Fairhaven, from Bridge Street to Washington Street, and heavy damage was reported from beach colonies in the Sconticut Neck and Pope Beach sections of the town.

"Though no abnormal tides were reported at New Bedford, water lashed ashore by the winds which reached a peak of at least 70 miles an hour during the height of the storm wrecked or washed away much nearby beach resort property, flooded south end homes, wrecked Dan's Pavilion and did other local damage.

"The total rainfall for the two day storm is 2.4 inches. Of this amount, 1.93 inch was recorded up to 4:00 p.m. yesterday, and the remainder up to 9:00 a.m. today.

"Barometer stood at 28.40 according to officials at Old Dartmouth Historical Society. Lowest ever recorded there and lower than 1938.

"The Mayor this afternoon estimated damage to New Bedford at more than $5,000,000. This city appeared to have been the hardest hit of any in New England."

w. 31 August to 14 September 1950. From "Standard Times," New Bedford.

" A howling Atlantic hurricane raced out of immobility and sideswiped Greater New Bedford last night as it turned seaward 50 miles east of Nantucket. The big blow, one gust of which was recorded at 100 miles an hour on New Bedford Municipal Airport wind instruments, buffeted Maritime and inland properties and left yards, highways and water fronts strewn with the toll of its force.

"Although the Greater New Bedford scene today was littered with the results of the wind's blast, damage in this area was not expected to come close to that left in the wake of the hurricane of September 14, 1944 or September 21, 1938. Damages reported were telephone and electric lines blown down, fences down, sewers and drains clogged, the pier washed away at Nonquit, etc."

x. 25-31 August 1954. From: "Standard Times", New Bedford.

"Peak of the storm in this area, according to hourly reports on the anemometer in the control tower of Northeastern Airlines at Municipal Airport, was reached between 9:30 and 11:30 a.m. Winds were clocked at 45 miles an hour and gusts at 85 miles an hour.

"Municipal Airport observers said they believed winds and gusts reached heights greater than those recorded hourly on the anemometers. One airport observer said winds reached 75 miles an hour with gusts at 100 miles an hour.

"City Engineer's office here reported a high water mark for yesterday at 10½ feet above mean high tide. This is about the same if not slightly higher than in the 1938 hurricane.

"Entire waterfront section from the pier up past Front Street and part way up the Union Street, Center Street and Rose Street hills was under water. The Fairhaven-New Bedford bridge was covered at the peak of the storm by more than 5 feet of water. Worst hit in New Bedford was the Cove Road section, where more than 20 homes were reported washed from their foundations. Also heavily hit was Padanarm Avenue in the south end. State Pier was completely covered with water estimated from 5 to 7 feet high. Piers 3 and 4 and Homer's wharf were submerged and Front Street along the waterfront area was covered with water about waist high. Approximately 20 cars were buried in water rooftop high on State Pier with water half submerging the watchman's shack at the pier entrance. Several cars also were submerged on City Pier, as were more than 25 vehicles along the Front Street and New Bedford-Fairhaven bridge entrance area.

"In New Bedford winds reached gale proportions at 9:00 a.m. Abnormally high tides accompanied the winds, inundating seashore areas with several feet of water before the storm began to abate.

"Total precipitation for yesterday's storm recorded here by the City Engineer Office was 1.87 inch.

"Greater New Bedford's third devastating hurricane in 16 years caused damage estimated at up to $50,000,000. New Bedford industries damages estimated to be at least $10,000,000."

y. 6-11 September 1954. From: "Standard Times," New Bedford.

"Winds of the season's second hurricane in 11 days whipped into New Bedford this forenoon with winds in gusts up to 80 miles an hour, and a barometer reading of 28.61 at 1:45 p.m.

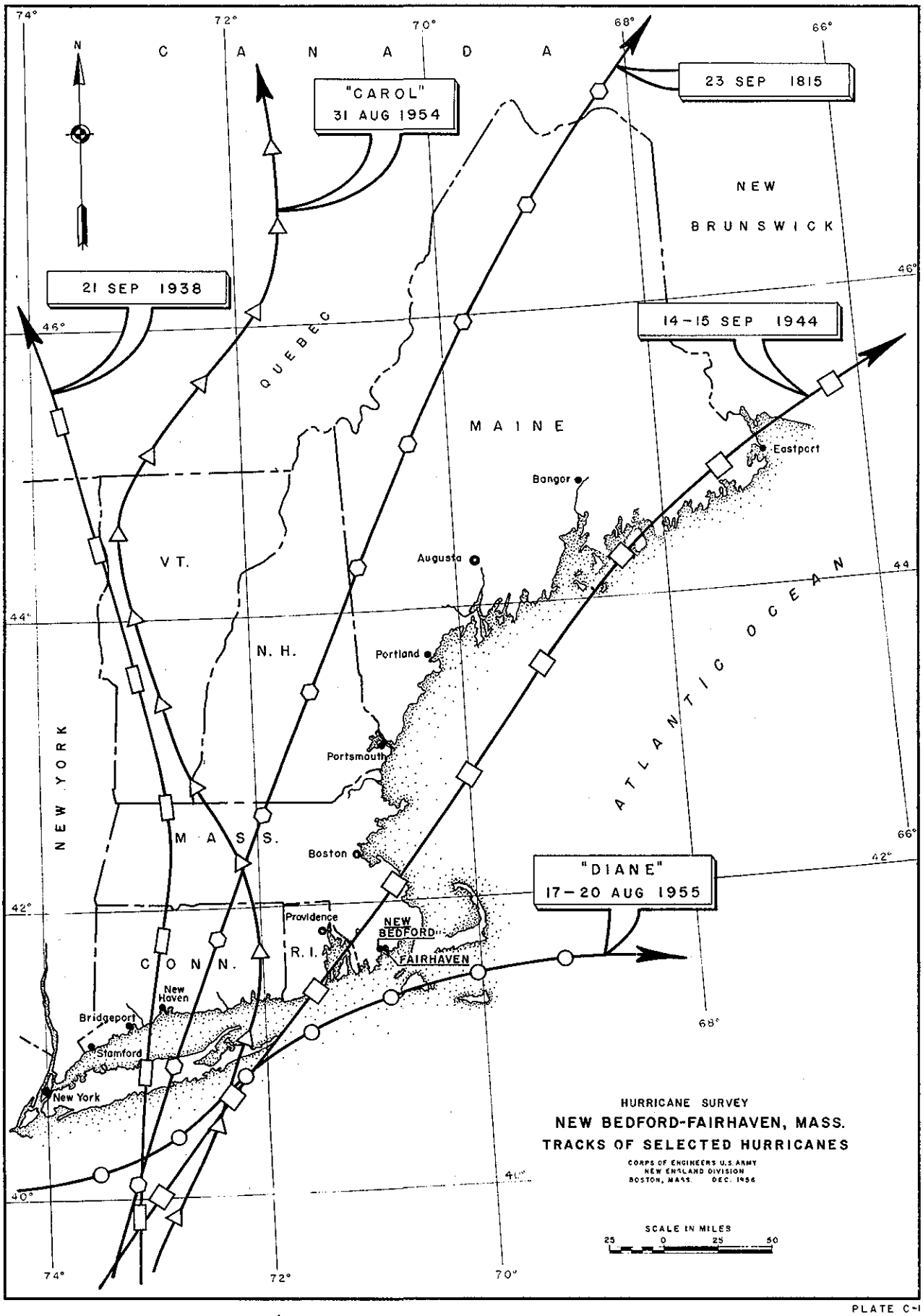
"Solid advance preparations and a last minute split in the hurricane eye, which hit during the ebbing tide, left Greater New Bedford, Cape Cod and the Islands with comparatively minor damage.

"As an added weather freak, most all damage was caused by the late afternoon backlash when winds whirled to an unexpected peak velocity of 90 miles an hour after the center of the storm had passed.

"When New Bedford-Fairhaven bridge was closed to all traffic at 3:30 p.m. after National Guardsmen reported to police high waves were washing over the bridge, New Bedford and Fairhaven police kept the bridge closed until 5:30 when winds died and hazardous driving conditions ceased."

C-4. HURRICANE TRACKS

The tracks of four notable hurricanes causing tidal flooding and serious damages in the survey area, namely those of September 1815, September 1938, September 1944, and August 1954 are shown on Plate C-1. The path of Hurricane "Diane," (1955) a storm which brought record rainfall to many areas in southern New England, is also shown on the plate.


74°
72°
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N
C A N A D A
"CAROL"
31 AUG 1954
23 SEP 1815
NEW
BRUNSWICK
21 SEP 1938
46°
14-15 SEP 1944
QUEBEC
MAINE
Eastport
Bangor
VT.
Augusta
44°
N. H.
Portland
ATLANTIC OCEAN
NEW YORK
Portsmouth
M A S S.
Boston
"DIANE"
17-20 AUG 1955
42°
Providence
NEW
BEDFORD
FAIRHAVEN
C O N N.
R. I.
New
Haven
Bridgeport
Stamford
New York
40°
HURRICANE SURVEY
NEW BEDFORD-FAIRHAVEN, MASS.
TRACKS OF SELECTED HURRICANES
CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956
SCALE IN MILES
25 0 25 50

PLATE C-1

APPENDIX D

FLOOD LOSSES AND BENEFITS

APPENDIX D

FLOOD LOSSES AND BENEFITS

GENERAL

D-1. DAMAGE SURVEYS

Damage surveys in the New Bedford-Fairhaven area, undertaken for the purpose of collecting data upon which economic studies of various considered proposals for hurricane-flood protection could be based, were started in September 1955. Essentially, the survey was a door-to-door inspection of the hundreds of industrial, commercial, residential, and other properties affected by tidal flooding in recent hurricanes. The information obtained included the extent of the areas flooded, descriptions of properties, including changed conditions since the 1954 hurricane, the nature and amount of damages, depth of flooding, high-water references, and relationships between 1954 and previous flood stages. Evaluations of damage were generally furnished by tenants or property owners and were then checked and, if unreasonable, were modified by the investigators. Sampling methods were used where properties of the same general type and subject to the same depth of flooding were encountered. Data on damages to public property, highways, utilities, and railroads were obtained from central headquarters and applied to field information. The survey area included the entire shore line of New Bedford, Fairhaven, and Acushnet from the Dartmouth town line on the west to Pope Beach east of Fort Phoenix. The Sconticut Neck and West Island area of Fairhaven, from Pope Beach eastward, is to be considered in a future report.

Sufficient data were obtained to derive losses at the 1954 flood stage, and a stage 3 feet higher. The stage of zero damage, that is, the stage where damage begins, was also determined. This stage was referenced to the 1954 flood level. Losses were also obtained for stages of floor levels and window openings where marked increases in damages occurred.

D-2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and by location. The types of loss under which the damages were listed included industrial, urban, (commercial, residential, and public), rural, highway, railroad, and utility. The losses were also recorded by subdivisions, such as city blocks within the flooded area, in order to provide a basis for later use in stage-loss and benefit analyses.

The losses evaluated in the survey were tangible, primary damages. Primary damages comprise the following: (1) physical losses, such as damage to structures, machinery, and stock, and cost of cleanup and repairs; and (2) non-physical losses, such as unrecovered loss of business, wages, or production; increased cost of operation; cost of temporary facilities; and increased cost of shipment of goods into or out of the inundated areas.

The primary loss resulting from physical damage, and a large part of the related non-physical loss, were determined by direct inspection of flooded properties and evaluation of the losses by either the property owner or field investigators, or both. The non-physical portions of the primary loss were often difficult to estimate on the basis of available information in a particular case. Where this condition existed, the non-physical losses were estimated, based on determined relationships between physical and non-physical losses for similar properties in the survey and other areas.

Monetary evaluations were not made of secondary damages or intangible losses. Secondary damages, incurred outside the immediate flooded area under study, include such items as increased cost of travel and shipment of goods, the loss of utilities and transportation facilities, and business losses. Intangible losses include items such as loss of life, hazards to health, and detrimental effects on the national security.

HURRICANE TIDAL-FLOOD DAMAGES

D-3. TIDAL-FLOOD LOSSES

The New Bedford and Fairhaven Harbor area, the hardest hit area on the southern coast of Massachusetts in past hurricanes, sustained enormous losses in Hurricane "Carol," 31 August 1954. As in the 1938 hurricane, the hurricane tidal surge in 1954 occurred nearly coincident with the peak of a gravitational spring tide and caused severe flooding throughout the shore areas of the Acushnet River, New Bedford Harbor, Clark Cove, and Buzzards Bay. The destructive tidal-flooding in 1954 rose 10 feet above mean high water in New Bedford Harbor, reaching a level 6 inches below the record tidal flood height experienced in 1938. In the survey area (from the New Bedford line at Clark Cove to Pope Beach in Fairhaven) tidal flooding caused total damages of $26,200,000. Over 1,800 structures suffered flood damages. Damage areas are described in Table D-2 and are shown on Plate D-1.

D-4. TYPE AND DISTRIBUTION OF LOSSES

Industrial concerns with plants located on low ground along the waterfront were particularly hard hit. Sixty-four companies, including 57 in New Bedford, suffered a loss of $19,520,000, which represents about 75 percent of the total damage in the survey area. The largest part of this loss was sustained by about 20 of the major concerns of New Bedford. A tabulation of 1954 experienced tidal-flood losses by towns and by type is shown in Table D-1 below, and by damage areas and by type in Table D-2 on the following page.

TABLE D-1

EXPERIENCED TIDAL-FLOOD LOSSES

HURRICANE "CAROL," 31 AUGUST 1954

New Bedford, Fairhaven, and Acushnet, Massachusetts

(Excluding Sconticut Neck and West Island)

City or Town	Losses in Thousands of Dollars				
	Urban	Rural	Industrial	Highway	Total
New Bedford	4,610	-	18,630	140	23,380
Fairhaven	1,790	-	600	120	2,510
Acushnet	10	10	290	-	310
Totals	6,410	10	19,520	260	26,200

In Areas I and II, above the Coggeshall Street Bridge, tidal flooding from the Acushnet River caused damages amounting to $7,400,000. All but 10 percent of this loss was experienced by 21 waterfront industries. The plants of the Aerovox Corporation (electronic components) and the Acushnet Process Company (rubber products) on Belleville Street suffered some of the heaviest losses in New Bedford. Salt water flooded some of these plants to a depth of 9 feet, causing extensive structural damage and heavy loss of equipment, stock, and finished goods. The Fibre Leather Company, Freedman and Son Shoe Company, and the Fairhaven Mills, inundated to depths of from 4 to 9 feet, also suffered heavy losses.

In the short distance between the Coggeshall Street Bridge, and the New Bedford-Fairhaven Bridge (Areas III and IV), the losses amounted to $5,400,000. Over $4,000,000 of this total was experienced by New Bedford industries. Two of the hardest hit concerns were the Revere Copper and Brass Company on North Front Street and the Wamsutta Mills (textiles) on Wamsutta Street. Damages to

TABLE D-2

EXPERIENCED TIDAL-FLOOD LOSSES

HURRICANE "CAROL," 31 AUGUST 1954

New Bedford, Fairhaven, and Acushnet, Massachusetts

(Excluding Sconticut Neck and West Island)

Area	Description	Losses in Thousands of Dollars				
		Urban	Rural	Industrial	Highway	Total
I	New Bedford, above Coggeshall Street Bridge	420	-	6,500	140	7,060
II	Fairhaven and Acushnet, above Coggeshall Street Bridge	30	10	300	-	340
III	New Bedford, Coggeshall Street to New Bedford-Fairhaven Bridge	630	-	4,430	-	5,060
IV	Fairhaven, Coggeshall Street to New Bedford-Fairhaven Bridge	340	-	-	-	340
V	New Bedford, New Bedford-Fairhaven Bridge to Clark Point	2,770	-	5,660	-	8,430
VI	Fairhaven, New Bedford-Fairhaven Bridge to Fort Phoenix	1,030	-	590	120	1,740
VII	New Bedford, Clark Cove Area	780	-	2,040	-	2,820
VIII	Fairhaven, Fort Phoenix to Pope Beach	410	-	-	-	410
	Total	6,410	10	19,520	260	26,200

residential and commercial properties in these areas amounted to almost $1,000,000.

The harbor area below the New Bedford-Fairhaven Bridge, extending to Clark Point in New Bedford and to Fort Phoenix in Fairhaven (Areas V and VI), was the scene of heavy residential, commercial, and industrial losses as well as serious losses to waterfront facilities and the New Bedford and Fairhaven fishing fleets. Industries in lower New Bedford sustained over $6,000,000 of the nearly $10,200,000 loss in these areas below the bridge. Two textile manufacturers on Cove Street, the Berkshire Hathaway Company and the Dartmouth Finishing Company, were heavily damaged by severe flooding. The Cornell-Dubilier Electric Corporation plant on Rodney French Boulevard, which experienced up to 6 feet of water in some buildings, also sustained heavy losses.

In the Clark Cove area of New Bedford (Area VII) industrial damage amounted to about $2,000,000. Tidal flooding caused heavy damage to nine textile companies in this area. The Marscot Plastic Company suffered severe losses from 5 feet of flooding in two of its plants.

Losses to residential properties in Fairhaven between Fort Phoenix and Pope Beach (Area VIII) amounted to over $400,000. Of some 150 cottages inundated by tidal flooding in this area, 25 were completely destroyed.

In addition to extensive residential, commercial, and industrial losses in the New Bedford-Fairhaven area, damages sustained by craft afloat and by automobiles in the flooded area accounted for considerable losses which were not included in the tabulations of damages, or were included only in part, since information on these losses was meager or unavailable. Available evidence indicates, however, that losses of this nature were substantial in both the 1938 and 1954 hurricanes.

D-5. RECURRING LOSSES

Stage-loss curves, referenced to the 1954 tidal flood level, have been developed as the basis for economic analysis. These stage-loss curves, prepared from data collected in the recent damage surveys, afford a means of determining the magnitude of recurring losses at any stage of flooding up to a stage 3 feet above that experienced in 1954. The difference between the experienced losses in the flood of 1954 and the recurring losses used in development of the stage-loss relationship reflects economic and physical changes in the area since 1954 as revealed by the damage survey.

A number of primary flood losses, both tangible and intangible, have not been included in the economic analyses of protective measures, even though these losses may be substantial in a given instance of tidal flooding. Tangible losses in this category are made up of (1) damages to vehicles either underway or parked on the street or in public or commercial parking lots; and (2) damages to small craft and vessels afloat at shore facilities, or on the open water within the protection area, which are subject to an indeterminate combination of wind, waves, and tide. These categories of losses consist of damages to items which are not always present in the same place, at the same time, or in the same quantity. To put losses in this category in perspective for analysis, would require a framework of multiple assumptions. However, the economic analysis does include an evaluation of the damages reported by local fishing interests covering partial losses to the fishing fleet.

The following paragraphs describe the economic and physical changes, in addition to price level changes, which are reflected in the computation of recurring flood losses.

The stage-loss relationship reflects an evaluation of the effectiveness of permanent and semi-permanent flood protection devices and measures, where they have been installed since 1954 at industrial concerns, commercial houses, and public buildings. These protective measures include the following: the permanent closure of windows and other openings below an approximate 1954 flood stage; provisions for gating discharge lines; the extension and reinforcement of existing walls; the construction of flood walls; the installation of pumps to control seepage and interior runoff; the evacuation of plant storage space susceptible to flooding; and the organization of flood mobilization plans to put into effect measures adopted to prevent loss of life and to minimize damages. Credit for these local protection measures influences the stage-loss relationship to a stage 1 foot below the stage of flooding experienced in 1954.

Credit for such measures at a recurring 1954 flood stage was not considered feasible because of the many unknown factors and inherent weaknesses in this type of protection. These unpredictable factors include the vulnerability of both walls and floors to the hydrostatic pressures created by a flood of 1954 magnitude, the possibility of overtopping, and the danger of a breakthrough under the battering of wind and wave-driven debris, which would allow the entry of salt water and thereby nullify the benefit of almost all other protective measures.

In addition to the possibilities of physical failure, the effectiveness of local plant protection is further weakened by

the critical importance of the time element involved in putting flood mobilization plans into effect. Owing to the heavy non-recoverable losses incurred by a complete plant shutdown, concerns are reluctant to put their plans into total operation until dangerous flooding is imminent. Considering the vagaries of hurricane movements, this delay can be disastrous. Optimum conditions, including an early hurricane warning at a time when an adequate number of personnel are available to set a plan into successful operation, must exist before full benefits can be realized from the local protective measures which have been adopted.

Recurring losses also reflect changes in the affected areas by reason of the complete destruction of property by hurricane flooding in 1954. However, an allowance has been made for normal recovery. Based on evidence of recovery noted in the damage surveys and on the rate of reconstruction in the area following the hurricane of 1938, a 30 percent recovery of loss potential, with additional allowance for increased costs, has been incorporated in the computation of recurring losses.

The stage-damage relationships found in the New Bedford-Fairhaven Harbor area are shown on Plate D-2.

A breakdown of the losses to be anticipated in the tidal-flood areas of New Bedford, Fairhaven, and Acushnet, and in the areas protected by hurricane Protection Plan "F," in the event of future hurricanes, are shown in Table D-3.

ANNUAL LOSSES AND BENEFITS

D-6. GENERAL

The total benefit of the plan to control hurricane tidal flooding in the New Bedford-Fairhaven Harbor area is made up of benefits from the prevention of flood damage and from the elimination of scare costs. The flood damage-prevention benefits are by far the most important. The annual benefits of such nature attributable to Hurricane Protection Plan "F" at New Bedford and Fairhaven have been determined by two different methods. The first method follows the standard practice of the Corps of Engineers and is based upon a determination of the frequency of hurricane tidal flooding in the area and a correlation of stage-damage, stage-frequency, and damage-frequency relationships. Benefits derived by this method equal the difference between annual losses under natural conditions and annual losses after construction of the project. The alternate method is based upon an estimate of the total losses which will be sustained in a 50-year period by the recurrence of flood stages caused by hurricanes equivalent in number and intensity to those which have hit

TABLE D-3

RECURRING HURRICANE TIDAL-FLOOD LOSSES

New Bedford, Fairhaven, and Acushnet, Massachusetts

(Excluding Sconticut Neck and West Island)

Equivalent Hurricane	Flood Stage (feet msl)	Location	Losses (1956 prices) Entire Flooded Area	Losses (1956 prices) Plan "F" Protected Area
August 1954	11.9	New Bedford	$24,550,000	$23,590,000
		Fairhaven	2,460,000	2,200,000
		Acushnet	330,000	330,000
		Total	$27,340,000	$26,120,000
September 1944	8.2	Total	$ 1,550,000	$ 1,550,000
September 1938	12.5	Total	$32,970,000	$31,760,000
Design	18.0	Total	$96,000,000	$91,600,000

the area during the past 50 years. A 50-year period has been adopted to provide a period which is comparable with the amortization period of the project. Benefits derived by the damage-frequency method have been used to determine the benefit-cost ratio.

D-7. AVERAGE ANNUAL TIDAL-FLOOD DAMAGES

Hurricane tidal-flood losses in the New Bedford-Fairhaven area have been converted to annual losses by correlating stage-damage, stage-frequency, and damage-frequency curves to provide a basis for comparison of annual benefits to annual costs. For the purpose of analyzing tidal-flood losses on an annual basis, a stage-frequency curve has been developed. It is based on the known peak elevations in three recent hurricanes, i.e., the hurricanes of 1938, 1944 and 1954, and on the estimated stages in five earlier hurricanes, all occurring within the past 141 years. See Plate D-3.

Recurring stage-damage data for individual properties, referenced to the peak elevations of the 1954 hurricane flood, have been summarized for the areas afforded protection by the proposed Plan "F." The stage-damage curve has been combined with stage-frequency data to develop a damage-frequency curve which has been plotted with damage as the ordinate and with percent-chance-of-occurrence (the reciprocal of frequency) as the abscissa. See Plate D-4. The area under this damage-frequency curve is a measure of the average annual loss. The annual loss in the New Bedford-Fairhaven Harbor area which will be protected by Plan "F" amounts to $949,200 (1956).

D-8. ANNUAL DAMAGE-PREVENTION BENEFITS

Average annual benefits from the prevention of tidal-flood damages have been derived by determining the difference between the annual losses under present conditions and those remaining after construction of the protection plan. On this basis, utilizing damage-frequency curves, the annual benefits to the plan from the prevention of flood damages amount to $943,800.

D-9. FIFTY-YEAR DAMAGE-PREVENTION BENEFITS

Three major hurricane tidal floods, those of 1938, 1944, and 1954, have occurred in the New Bedford-Fairhaven area within the past 18 years. A recurrence within the next 50 years of the flood stages occasioned by these three hurricanes, under present (1956) economic conditions, would cause an estimated total loss of $59,430,000 in the area protected by the project. In a recurrence of the two hurricanes which produced the highest flood stages, namely, those of 1938 and 1954, operation of Plan "F" will prevent losses amounting to $31,760,000 and $26,110,000, respectively. Losses amounting to $1,550,000 will be prevented in the event of a future hurricane of 1954 magnitude. Assuming the recurrence of these three hurricanes in a 50-year period, total preventable damages would amount to $59,420,000 or $1,188,000 annually.

D-10. SCARE COST BENEFITS

In addition to actual tidal-flood damage, significant losses are sustained in areas subject to tidal-flooding due to the cost of setting temporary protective measures into operation following the receipt of hurricane warnings whether or not the areas are flooded. Based on data gathered in the course of damage surveys in the New Bedford-Fairhaven area, it is estimated that 25 percent of the commercial establishments and 50 percent of the industrial concerns in the flooded area attempt to minimize their potential losses through temporary preventive measures. The estimated bene-

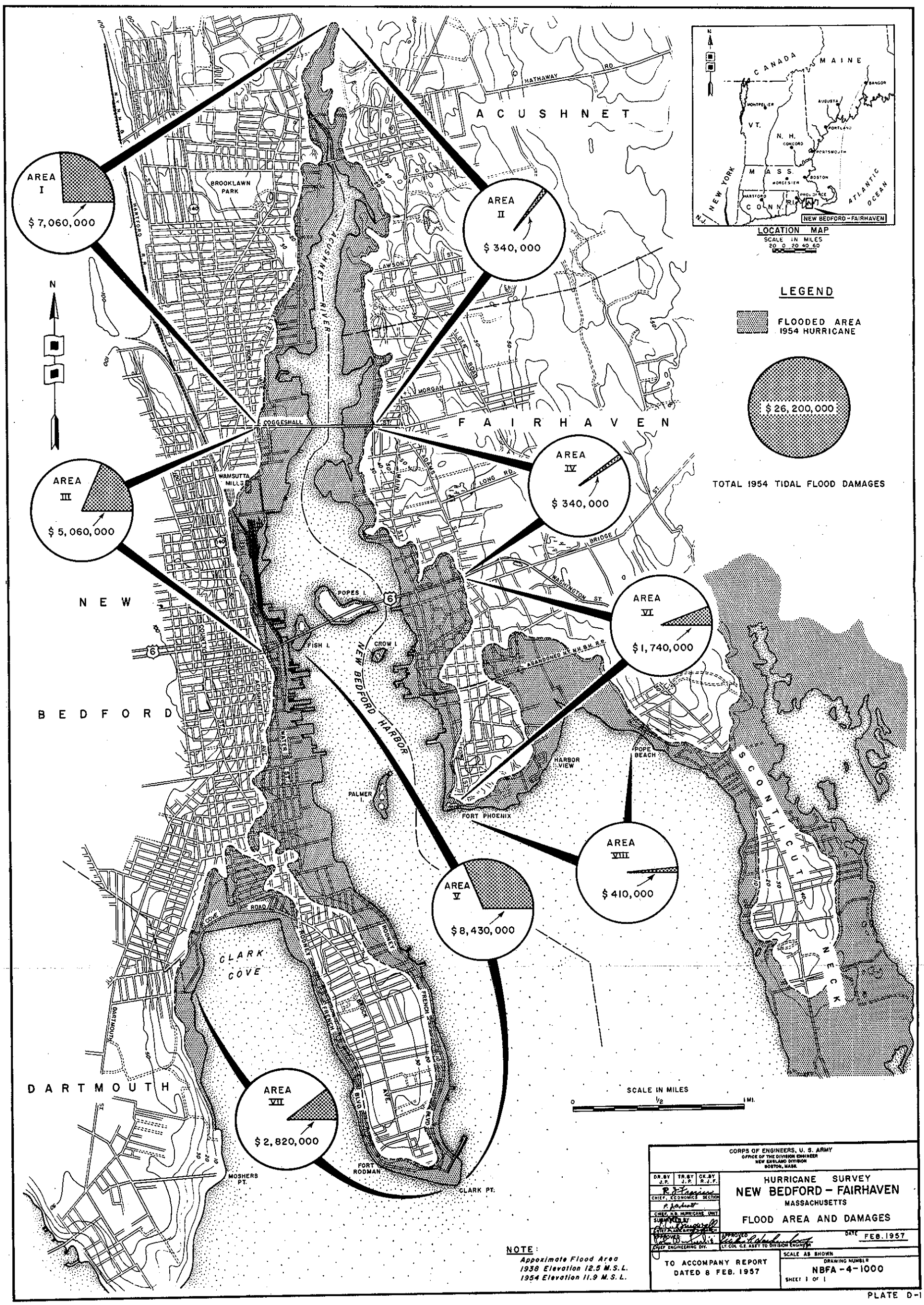
fits to Plan "F," by eliminating the scare costs incurred in a single hurricane warning, amount to $147,000 (1956). Based on a frequency of three hurricane warnings in a 10-year period, the average annual benefit from the elimination of scare costs amounts to $44,100 (1956).

D-11. ENHANCEMENT BENEFITS

A field investigation of the flooded areas in New Bedford, Fairhaven, and Acushnet was made for the purpose of determining the extent of enhancement benefits that could be credited to the project through new or higher use of land made possible by reason of the construction of Plan "F." This investigation indicated that the benefits of this nature would be practically negligible.

D-12. SUMMARY OF BENEFITS

Total annual benefits attributable to the protection provided by Plan "F" include $943,800 from the prevention of flood damages and $44,100 from the elimination of scare costs, a total of $987,900.



NOTE:
Approximate Flood Area
1938 Elevation 12.5 M.S.L.
1954 Elevation 11.9 M.S.L.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY J.P. | TR. BY J.P. | CK. BY R.J.F.

CHIEF, ECONOMICS SECTION
CHIEF, N.D. HURRICANE UNIT
CHIEF, PLANNING BRANCH
CHIEF ENGINEERING DIV.

APPROVED
LT. COL. C.E. ASST TO DIVISION ENGINEER

DATE FEB. 1957

HURRICANE SURVEY
NEW BEDFORD – FAIRHAVEN
MASSACHUSETTS
FLOOD AREA AND DAMAGES

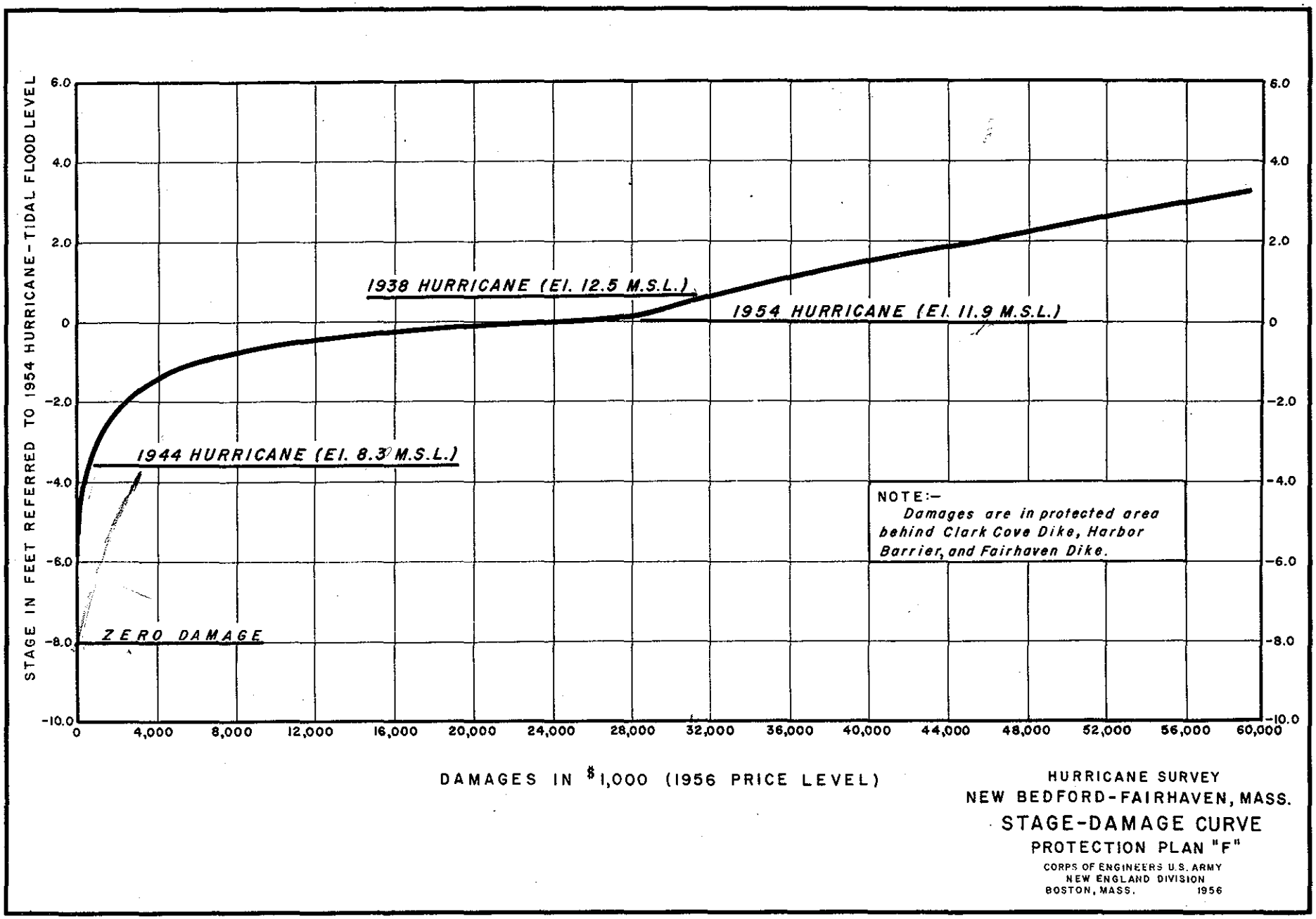
TO ACCOMPANY REPORT
DATED 8 FEB. 1957

SCALE AS SHOWN

DRAWING NUMBER
NBFA-4-1000

SHEET 1 OF 1

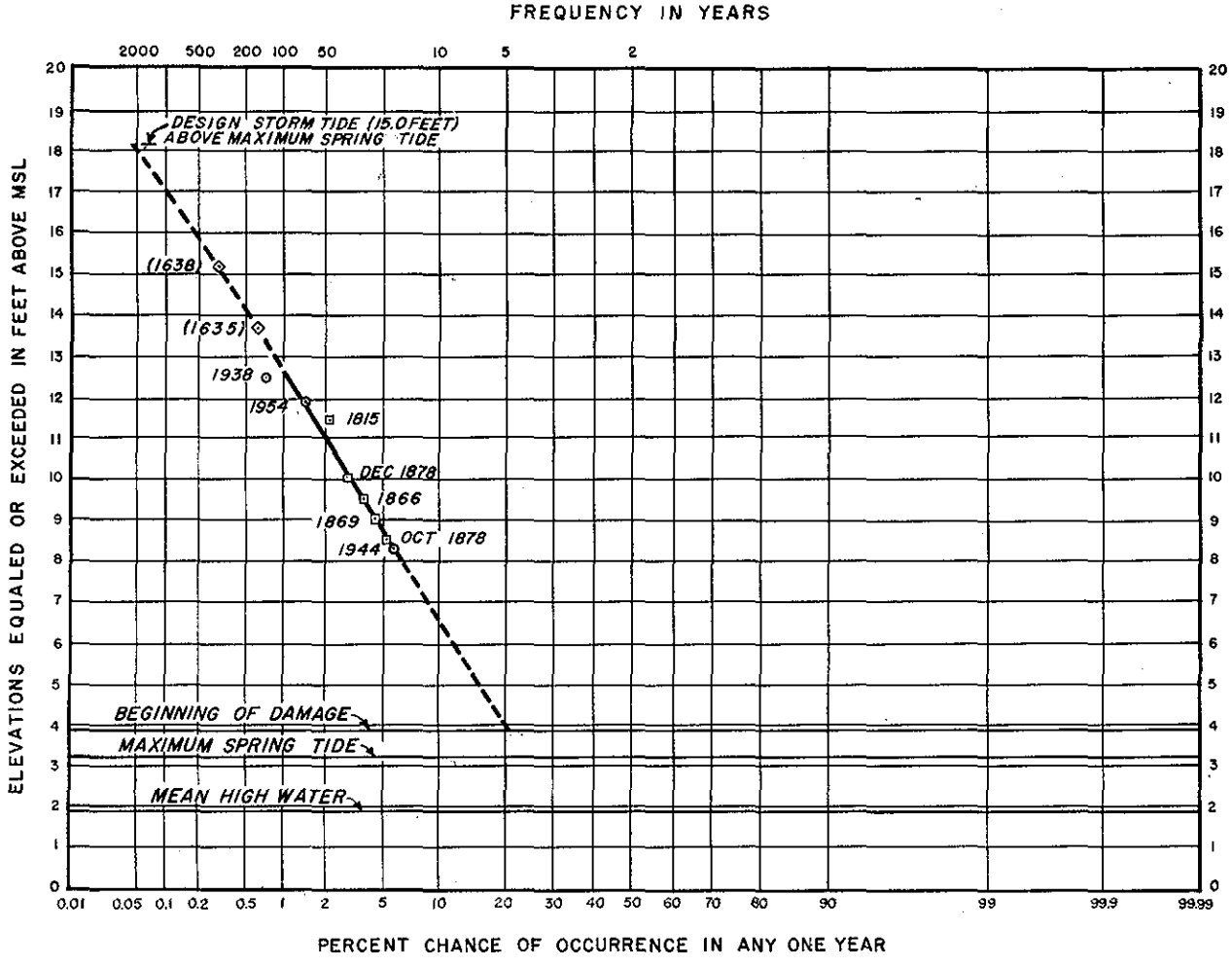
PLATE D-1



HURRICANE SURVEY
NEW BEDFORD-FAIRHAVEN, MASS.
STAGE-DAMAGE CURVE
PROTECTION PLAN "F"

CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. 1956

PLATE D-2



LEGEND

⊙ ELEVATION FROM SURVEY OF HIGH-WATER MARKS

⊡ ELEVATION ESTIMATED FROM HISTORICAL DESCRIPTIONS OF GENERAL NATURE

◇ FREQUENCY BASED ON PERIOD 1635-1955

HURRICANE SURVEY

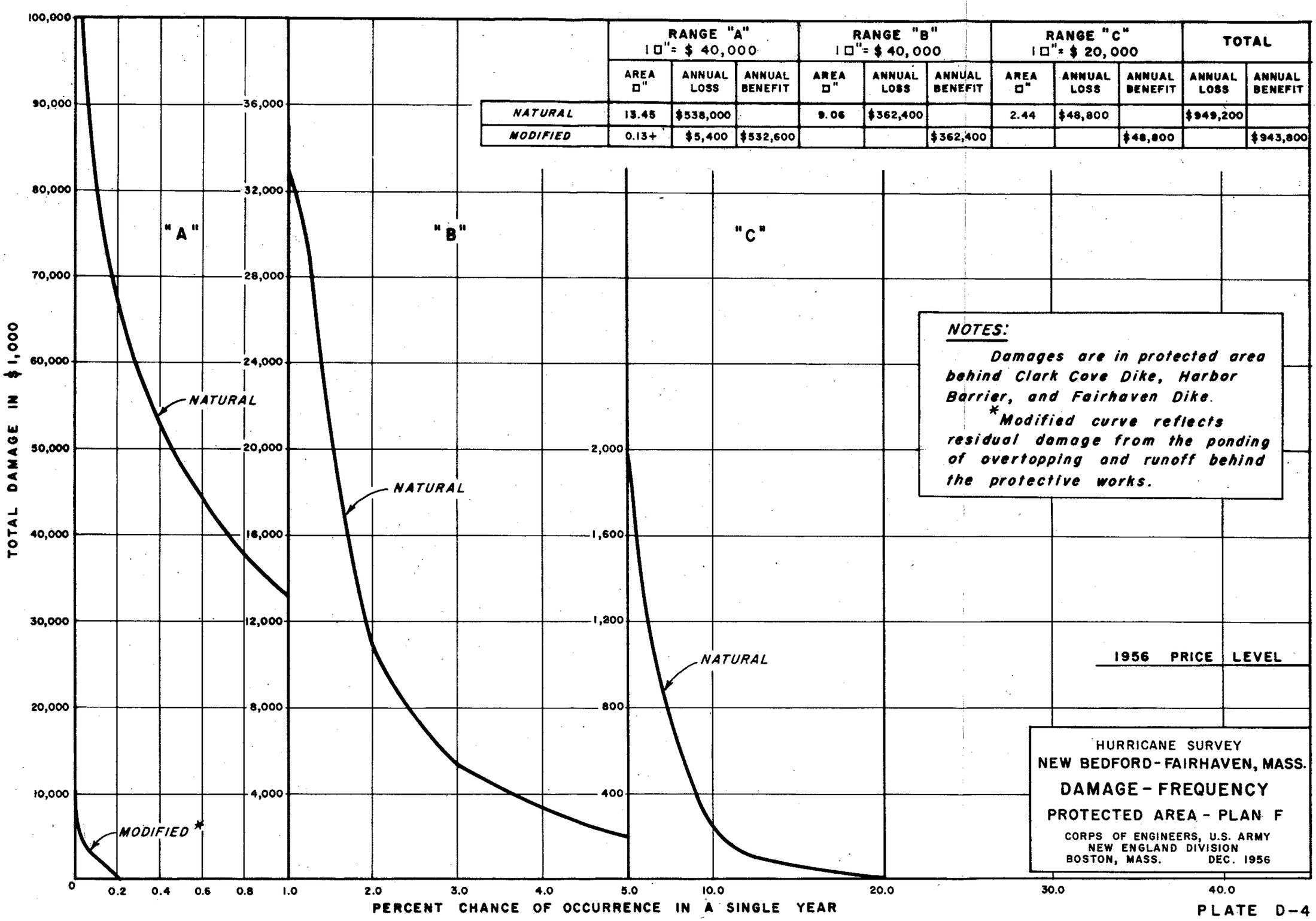
NEW BEDFORD-FAIRHAVEN, MASS.

ELEVATION-FREQUENCY CURVE DAMAGING HURRICANES 1815 – 1955

CORPS OF ENGINEERS U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956

PLATE D-3

	RANGE "A" 1□"= $ 40,000			RANGE "B" 1□"= $ 40,000			RANGE "C" 1□"= $ 20,000			TOTAL	
	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL	13.45	$538,000		9.06	$362,400		2.44	$48,800		$949,200	
MODIFIED	0.13+	$5,400	$532,600			$362,400			$48,800		$943,800



NOTES:

Damages are in protected area behind Clark Cove Dike, Harbor Barrier, and Fairhaven Dike.

**Modified curve reflects residual damage from the ponding of overtopping and runoff behind the protective works.*

1956 PRICE LEVEL

HURRICANE SURVEY
NEW BEDFORD - FAIRHAVEN, MASS.
DAMAGE - FREQUENCY
PROTECTED AREA - PLAN F

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS. DEC. 1956

PLATE D-4

APPENDIX E

DESIGN AND COST ESTIMATES

APPENDIX E

DESIGN AND COST ESTIMATES

INTRODUCTION

E-1. This appendix presents details of design features and cost estimates for the selected plan of hurricane protection for the New Bedford and Fairhaven Harbor area (Plan "F"). The principal features of the plan are shown on Plates E-1 through E-6.

SURVEYS AND EXPLORATIONS

E-2. The design and cost estimates for the selected plan are based on topographic and hydrographic surveys and subsurface explorations accomplished in 1955 and 1956. A total of 57 borings, 27 on land and 30 underwater, were made along considered alignments of various plans of protection.

DESIGN CRITERIA

E-3. The structures have been designed to withstand a design hurricane producing a still-water elevation of 18.0 feet msl, accompanied by maximum waves of from 12 to 13 feet in the harbor and in Clark Cove and from 5 to 6.5 feet at the Fairhaven Dike. The top elevation of 22.0 feet msl for the structures in New Bedford and Fairhaven Harbor and Clark Cove, and 20.0 feet msl for Fairhaven Dike, were selected to provide protection against the design hurricane stillwater and waves. At the instant of a maximum wave during the rare occurrence of a design hurricane the top of runup would be 8 or 9 feet above the top of the main harbor barrier and Clark Cove dike and 1 to 2.5 feet above the Fairhaven Dike. With a recurring 1938 or 1954 hurricane the maximum wave runup would just reach the top of the barrier. This infrequent overtopping would not appreciably reduce the effectiveness or safety of the project structures. For detailed discussion of the design hurricane and wave overtopping see Appendix B.

SELECTED PLAN OF PROTECTION (PLAN "F")

E-4. DESCRIPTION OF PLAN

a. General. The selected plan of protection consists of a barrier with gated opening, about 4,580 feet long, crossing New Bedford and Fairhaven Harbor at the south end of Palmer Island;

a closure dike and wall, 4,170 feet long, extending southerly from the New Bedford end of the harbor barrier; and supplemental closure dikes and walls along the shore of Clark Cove and in Fairhaven, about 5,860 and 3,620 feet long, respectively, as shown on the General Plan, Plate E-1. Included in the plan of improvement are the following structures:

(1) A 150-foot wide gated navigation opening, between Palmer Island and Fairhaven, across the existing channel.

(2) A gated tidal conduit through the section of barrier between the New Bedford shore and Palmer Island.

(3) Stoplog structures with 30 by 13-foot openings at three highway crossings in New Bedford.

The alignment and location of all structures are shown on Plates E-2, E-5, and E-6.

b. Barrier. The main harbor barrier will be of earth-fill, rock-faced construction with a top elevation of 22.0 feet msl and a top width of 20 feet. The top surface is paved and provided with guard rails to serve as an access road to the navigation gates and the gated conduit. An 8-foot berm at an elevation of 16.0 feet msl, on the inner slope of the barrier, will afford access to the gate structures in times of a hurricane. For details see Plates E-2 and E-3.

(1) The 150-foot navigation opening will be provided with sector gates which are closed during a hurricane. They will be contained in recesses in the abutments during normal periods. The gates consist of two similar leaves with a radius of 90 feet and an over-all height of 61 feet. Details of the gates are shown on Plate E-4.

(2) The gated conduit structure will consist of four 7-foot by 9-foot conduits, side by side. A control room, located on the harbor slope of the barrier, will house the gates and operating equipment. During normal periods, the gates will remain in an open position, allowing for the free passage of tidal waters into and out of the inner harbor. Details of the conduit structure are shown on Plate E-3.

c. Dikes and Walls. The dikes along the west shore of New Bedford and Fairhaven Harbor, and in the Clark Cove area, will be of earth-fill, rock-faced construction with a top elevation of 22.0 feet msl and a top width of 10 feet. The Fairhaven Dike

will be constructed of earth-fill with rock-facing on the seaward slope and on the top and seeded topsoil on the landward slope. It will have a top elevation of 20.0 feet msl and a top width of 10 feet. The concrete walls at the southern end of the dike extension to the harbor barrier, and at both ends of the Clark Cove Dike will be gravity type. They will have a top elevation varying from 18.0 to 22.0 feet msl. See Plates E-2, E-5, and E-6.

d. Pertinent Data. Pertinent data on Plan "F" structures are summarized in Table E-1 below.

TABLE E-1

PERTINENT DATA

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

Main Harbor Barrier and Dike

Barrier

Type: Earth-fill, rock toes and rock-faced slopes	
Length (excluding gated opening)	4,430 feet
Top elevation	22.0 feet msl
Top width	20 feet
Average height	29 feet
Side slopes	1 on 2.5

Navigation Gates

Type: Sector	
Width of navigation opening	150 feet
Number of gates	2
Interior angle of each gate	60°
Radius of each gate	90 feet
Outer circumference of each gate	94.5 feet
Top elevation	22 feet msl
Sill elevation	-39 feet msl
Height of each gate	61 feet

Gated Conduit

Number of sluice gates	4
Size of sluice gates	7 by 9 feet
Sill elevation of sluice gates	-6.0 feet msl

TABLE E-1 (Cont'd)

Main Harbor Barrier and Dike

Dikes

Type: Earth-fill, rock-faced slopes	
Length	3,135 feet
Top elevation	22.0 feet msl
Top width	10 feet
Average height	19 feet
Side slopes	1 on 1.5

Concrete Walls

Type: Gravity	
Length	1,035 feet
Top elevation	18.0 - 22.0 feet msl

Stoplog Structures

Number	1
Width of opening	30 feet
Height of opening	13 feet

Clark Cove Dike

Dike

Type: Earth-fill, rock-faced slopes	
Length	4,610 feet
Top elevation	22.0 feet msl
Top width	10.0 feet
Average height	15 feet
Side slopes	1 on 1.5

Walls

Type: Gravity	
Length	1,250 feet
Top elevation	18.0 - 22.0 feet msl

Stoplog Structures

Number	2
Width of opening	30 feet
Height of opening	13 feet

TABLE E-1 (Cont'd)

Fairhaven Dike

Type: Earth-fill, rock-faced on top and seaward side, seeded topsoil on land side	
Length	3,620 feet
Top elevation	20 feet msl
Top width	10 feet
Average height	9 feet
Side slopes	1 on 1.5 and 1 on 2

E-5. MODIFICATION TO SEWERAGE AND DRAINAGE FACILITIES

a. Modifications to Sewer Lines. A sluice gate will be installed in the city of New Bedford's main intercepting sewer, at the intersection of Rodney French Boulevard and Woodlawn Street, in order to prevent hurricane tidal-flood water from entering this line and flooding the area behind the harbor barrier and the Clark Cove Dike. A second sluice gate will be installed in this sewer line farther north, at the intersection of Second and Blackmer Streets, and a diversion line constructed along Blackmer Street to carry the flow to the area above the harbor barrier. This diversion will be used only during times of a hurricane.

b. Modifications to Drainage Lines. Existing drainage pipes under the proposed dikes will be replaced with cast-iron pipes in order to carry the added weight of the dikes. Each line will be provided with a cast iron flap valve to prevent the entry of tidal waters. In order to provide normal surface drainage in the Clark Cove area, drop-inlet basins will be installed on the landward side of the dike and minor regrading will be accomplished. A paved drainage channel will be constructed behind the dike extension to the harbor barrier and a conduit installed under the access ramp to the barrier at Gifford Street. This channel and conduit will conduct surface runoff to the harbor area above the barrier at times of a hurricane. At the Fairhaven Dike, a 3 by 4-foot gated culvert will replace the existing culvert to provide normal drainage for the area behind the dike and to prevent the entry of hurricane tides.

E-6. LANDS AND DAMAGES

The cost of furnishing necessary lands and rights-of-way, which will be one requirement of local cooperation, has been estimated upon the basis of a field reconnaissance and the application of current

market values as determined from a study of a number of recent sales in the general area. The estimate includes allowances for resettlement costs, the payment of severance damages, and acquisition costs. The lands and improvements to be acquired, and the land upon which either temporary or permanent easements will be secured, are summarized below:

Land:

Acquired in fee, for structures	45.9 acres
Construction easements, temporary	10.5 acres
Permanent flowage easements	14.0 acres
Total	70.4 acres

Improvements:

One boatyard
Five garages
Two residences, including back-yard improvements such as fireplaces.

E-7. RELOCATIONS

The construction of Plan "F" structures will not require the relocation of any highways, railroads, or water lines. Four underwater power cables which now cross the harbor at the north end of Palmer Island will require removal or relocation. The local utility company is considering the possibility of abandoning the two older cables when construction of Plan "F" is initiated.

E-8. GEOLOGY OF SITE

The geology of the area and the foundation conditions for the protective structures in Plan "F" are discussed in Appendix A. The results of the subsurface explorations are shown on Plates A-1 through A-4.

rev.

E-9. AVAILABLE MATERIALS

Information on the availability of required construction materials in the New Bedford area is contained in Appendix A. It has been estimated that about 50 percent of the material taken from the excavation of the temporary bypass channel will be stockpiled for use in the construction of the barrier and dikes. Approximately 70 percent of the required earth fill will come from this source.

E-10. PLAN OF CONSTRUCTION

The structures in Plan "F" will require about 2½ years to construct and to put into operation. The construction schedule, predicated on the erection of the navigation gates and gate structures in the dry, by cofferdamming, and by the provision of a temporary bypass channel for navigation during the construction period, will be generally as follows:

a. During the first year, the bypass channel will be dredged, the cofferdam constructed in the existing channel, and the inclosed area unwatered. The gated conduit will be built, and the gate abutments and the barrier from the New Bedford shore to the cofferdam will be constructed to an elevation of about five feet above msl or about three feet above mhw.

b. Completion of the gate structure, installation and testing of gates and equipment, and removal of the cofferdam will be accomplished during the second year or early in the third year. The barrier will then be completed to an elevation of 22.0 feet above msl.

c. Other features of the project, such as land dikes, walls, and appurtenant structures, will be constructed concurrently with the barrier and the navigation gates.

rev.

BASIS OF ESTIMATES OF FIRST COST AND ANNUAL CHARGES

E-11. COST ESTIMATES

The cost of Plan "F" has been estimated on the basis of a design which will provide economical and secure structures. Estimates of quantities have been made on the basis of the typical cross sections and details shown on Plates E-2 through E-6. Earth borrow items include stripping of borrow areas, spoil, compaction in fill, and loss from borrow to fill.

E-12. UNIT PRICES

Unit prices are based on averages for similar types of projects either constructed, under construction, or under contract in New England, and, where applicable, similar construction in other parts of the country. Adjustments have been made for the availability and locations of material required. The adopted unit prices, which are on a 1956 price level, also reflect adjustments to include minor items of work, such as the installation of signal lights on the gate structure, which do not appear as separate items in the cost estimates.

E-13. CONTINGENCIES, ENGINEERING AND OVERHEAD

The estimate includes a 15 percent allowance to cover contingencies. The cost of engineering, design, supervision, and administration are estimated lump sums based on knowledge of the site and experience. These items for each structure are shown in Table E-2 on the following pages.

E-14. ANNUAL CHARGES

The estimate for annual charges is based on 2.5 percent interest on the total investment and amortization of the investment over a period of 50 years. The Federal investment includes the first cost plus 2.5 percent interest for one-half of the estimated construction period of 2½ years. No allowance for the loss of taxes on lands is included in the annual charges since a large percentage of the lands are publicly owned. The loss of taxes from the acquisition of land now privately owned would be small. Costs of maintenance and operation of the projects are based on a knowledge of this site and costs of similar projects.

FIRST COSTS AND ANNUAL CHARGES

E-15. FIRST COSTS

The first cost of Plan "F" is estimated at $17,200,000 of which $15,490,000 would be borne by the United States and local interests would contribute in cash $1,560,000 and provide lands, rights-of-way and necessary relocations at an estimated cost of $150,000, a total local contribution of $1,710,000. The costs of the individual structures are shown in detail in the following table, Table E-2. Detailed breakdowns of the estimates, by principal features of the work, and by quantities and unit prices, are also shown in Table E-2.

E-16. ANNUAL CHARGES

The total annual charges for Plan "F" amount to an estimated $691,000. Of this amount, $619,000 represents Federal annual charges and $72,000, non-Federal. The determination of annual charges is shown in Table E-3.

TABLE E-2

ESTIMATED FIRST COSTS
(1956 Price Level)

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
Main Harbor Barrier and Dike				
Preparation of site	7	acre	L.S.	$ 1,000
Earth excavation, channel	550,000	cu yd	$1.50	825,000
Earth excavation, common				
Dikes	2,000	cu yd	1.00	2,000
Walls	3,000	cu yd	2.00	6,000
Earth excavation, borrow	95,000	cu yd	1.20	114,000
Earth excavation, stockpiled material	220,000	cu yd	0.70	154,000
Earth fill	280,000	cu yd	0.30	84,000
Crushed stone, 6" max.	54,000	cu yd	7.00	378,000
Bedding stone, 300-600 lb.	40,000	cu yd	7.00	280,000
Rock fill, 3-6 ton stone	100,000	cu yd	10.00	1,000,000
Rock fill, 3-ton maximum	33,000	cu yd	10.00	330,000
Rock fill, quarry-run stone	215,000	cu yd	8.00	1,720,000
Concrete, mass	3,000	cu yd	40.00	120,000
Stoplog structure	1	job	L.S.	12,000
Conduit and gates	1	job	L.S.	260,000
Navigation gates				
Cofferdam and unwatering	1	job	L.S.	1,075,000
Earth excavation	70,000	cu yd	2.00	140,000
Rock excavation	3,000	cu yd	15.00	45,000
Concrete reinforced, below El. -39.0	28,000	cu yd	50.00	1,400,000
Concrete reinforced, above El. -39.0	22,500	cu yd	60.00	1,350,000
Gates and equipment*	1	job	L.S.	1,550,000
Modifications to drainage facilities	1	job	L.S.	175,000
Guard rail	9,000	ft	5.00	45,000
Pavement	15,000	sq yd	3.00	45,000
Subtotal				$11,111,000
Contingencies				1,666,000
				$12,777,000
Engineering and design				894,000
				$13,671,000
Supervision and administration				1,094,000
Total Cost - Main Harbor Barrier and Dike				$14,765,000

*Includes aids to navigation

TABLE E-2 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
		Clark Cove Dike		
Preparation of site	6	acre	L.S.	$ 2,000
Earth excavation, common	40,000	cu yd	1.00	40,000
Earth excavation, structure	6,000	cu yd	2.00	12,000
Earth excavation, borrow	35,000	cu yd	1.20	42,000
Earth excavation, stockpiled material	30,000	cu yd	0.70	21,000
Earth fill	60,000	cu yd	0.30	18,000
Crushed stone, 6" max.	8,000	cu yd	7.00	56,000
Bedding stone, 300-600 lb.	20,000	cu yd	7.00	140,000
Rock fill, 3-6 ton stone	28,000	cu yd	10.00	280,000
Rock fill, 3-ton max. stone	9,000	cu yd	10.00	90,000
Rock fill, quarry-run stone	1,000	cu yd	8.00	8,000
Concrete, mass	7,000	cu yd	40.00	280,000
Stoplog structures	2	ea	13,000.00	26,000
Modification to drainage facilities	1	job	L.S.	185,000
Subtotal				$1,200,000
Contingencies				180,000
				$1,380,000
Engineering and design				97,000
				$1,477,000
Supervision and administration				118,000
Total Cost - Clark Cove Dike				$1,595,000

TABLE E-2 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
Fairhaven Dike				
Preparation of site	6	acre	L.S.	$ 3,000
Earth excavation, common	21,000	cu yd	1.00	21,000
Earth excavation, borrow	20,000	cu yd	1.20	24,000
Earth excavation, stockpiled material	30,000	cu yd	0.70	21,000
Earth fill	50,000	cu yd	0.30	15,000
Bank-run gravel	6,000	cu yd	3.00	18,000
Bedding stone, 40-100 lb.	5,000	cu yd	7.00	35,000
Rock fill, quarry-run stone	9,000	cu yd	8.00	72,000
Topsoil	2,000	cu yd	5.00	10,000
Seeding	2	acre	500.00	1,000
Gated culvert	1	job	L.S.	12,000
Subtotal				$ 232,000
Contingencies				36,000
				$ 268,000
Engineering and design				19,000
				$ 287,000
Supervision and administration				23,000
Total Cost - Fairhaven Dike				$ 310,000
Modification to Sanitary Sewerage Facilities				
Installation of gates and construction of diversion line	1	job	L.S.	$ 285,000
Contingencies				43,000
				$ 328,000
Engineering and design				25,000
				$ 353,000
Supervision and administration				27,000
Total Cost - Modification to Sanitary Sewerage Facilities				$ 380,000

TABLE E-2 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
Lands and Damages				
Land (in fee)	45.9	acre	L.S.	$ 29,000
Construction easements	10.5	acre	L.S.	3,000
Flowage easements	14.0	acre	L.S.	1,000
Improvements acquired	1	job	L.S.	35,000
Severance damage	1	job	L.S.	6,000
Subtotal				$ 74,000
Contingencies				10,000
				$ 84,000
Resettlement cost				3,000
Acquisition costs				23,000
Total Cost - Lands and Damages				$ 110,000
Relocations				
Relocations of four cables between Palmer Island and Fairhaven	1	job	L.S.	$ 40,000
Summary				
Main Harbor Barrier and Dike				$14,765,000
Clark Cove Dike				1,595,000
Fairhaven Dike				310,000
Modifications to Sanitary Sewerage Facilities				380,000
Lands and Damages				110,000
Relocations of Power Cables				40,000
Total First Cost				$17,200,000 (1)
Estimated First Cost to U. S.				$15,490,000
Estimated First Cost to Local Interests				$ 1,710,000

(1) Includes local cash contribution of $1,560,000 representing the estimated present worth of a future annual cost of $55,000 to the United States for operation and maintenance of the Harbor barrier and gates, including major replacements, and an estimated cost of $150,000 for lands, rights-of-way, and relocations to be borne by local interests.

TABLE E-3

ESTIMATED ANNUAL CHARGES
(1956 Price Level)

HURRICANE PROTECTION PLAN "F"

New Bedford and Fairhaven Harbor, Massachusetts

Federal Investment

Total Federal first cost		$15,490,000
Interest during construction		484,000
Total Federal Investment		$15,974,000

Federal Annual Charges

Interest on investment, 2.5%		$ 400,000	
Amortization, 1.026%		164,000	
Major replacements		4,000	
Maintenance and operation			
Salaries	$20,000		
Transportation and supplies	5,000		
Embankment and general	4,000		
Concrete features	6,000		
Gates and accessories	16,000		
		51,000	
Total Federal Annual Charges			$ 619,000

Non-Federal Investment

Contributed funds	$1,560,000	
Lands, easements, and rights-of-way	110,000	
Cable relocation	40,000	
Total non-Federal first cost	$1,710,000	
Interest during construction	54,000	
Total Non-Federal Investment		$1,764,000

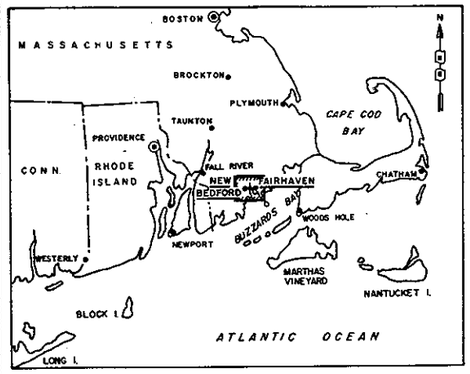
TABLE E-3 (Cont'd)

Non-Federal Annual Charges

Interest on investment, 2.5%		$ 44,000	
Amortization, 1.026%		18,000	
Major replacements		2,000	
Maintenance and operations			
Salaries	$ 1,000		
Transportation and supplies	500		
Embankment and general	2,500		
Concrete features	2,000		
Gates and accessories	2,000		
		8,000	
Total Non-Federal Annual Charges			$ 72,000
TOTAL ANNUAL CHARGES			$ 691,000
TOTAL ANNUAL BENEFITS (FROM APPENDIX D)			$ 987,900
RATIO OF ANNUAL BENEFITS TO ANNUAL CHARGES			1.4 to 1.0

CORPS OF ENGINEERS

U. S. ARMY



LOCATION MAP

SCALE IN MILES 10 0 10 20 30

PLAN

SCALE IN FEET 500 0 500 1000 1500 2000

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
H.M.G.	H.R.	J.L.T.

PROJECT ENGINEER

CHIEF, H.B. HURRICANE UNIT

SUPERVISED BY

CHIEF PLANNING BR.

APPROVED

CHIEF ENGINEERING DIV.

HURRICANE SURVEY

NEW BEDFORD-FAIRHAVEN, MASS.

PROTECTION PLAN "F"

GENERAL PLAN

APPROVED

LT. COL. C.E. ASST. TO DIVISION ENGINEER

DATE FEB. 1957

TO ACCOMPANY REPORT DATED 8 FEB. 1957

SCALE: 1" = 500'

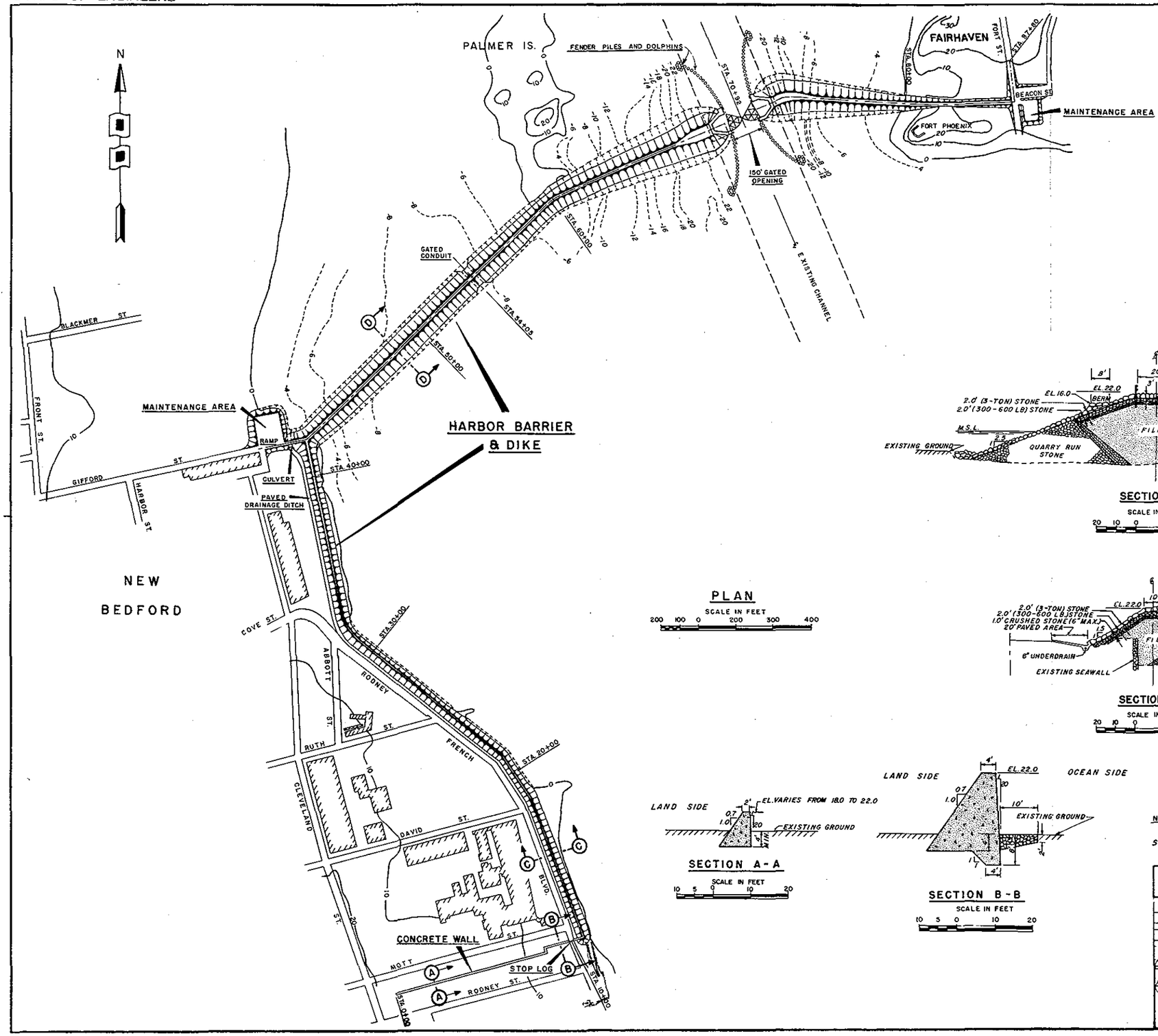
DRAWING NUMBER NBFA-1-1001

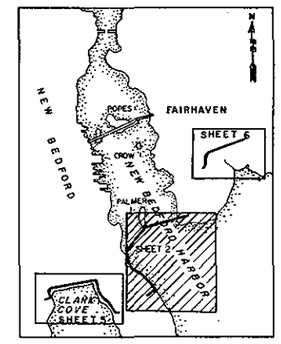
SHEET 2 OF 2

PLATE E-1

CORPS OF ENGINEERS

U. S. ARMY





LOCATION MAP

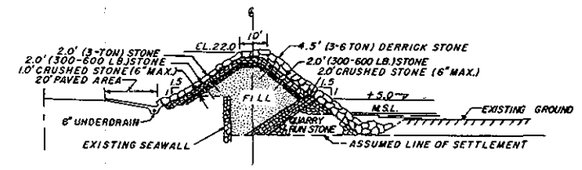
SCALE IN MILES 0

SECTION D-D

SCALE IN FEET 20 10 0 20 40

PLAN

SCALE IN FEET 200 100 0 200 300 400



SECTION C-C

SCALE IN FEET 20 10 0 20 40

SECTION A-A

SCALE IN FEET 10 5 0 10 20

SECTION B-B

SCALE IN FEET 10 5 0 10 20

NOTE:

Elevations are in feet and are referred to Mean Sea Level Datum.

CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR. BY P.H.G.	TR. BY H.H.G.	CH. BY M.J.K.

PROJECT ENGINEER

CHIEF, N.E. HURRICANE UNIT

SUBMITTED BY

APPROVED

APPROVED

DATE FEB. 1957

HURRICANE SURVEY
NEW BEDFORD-FAIRHAVEN, MASS.
HARBOR BARRIER AND DIKE
PLAN AND SECTIONS

TO ACCOMPANY REPORT DATED 8 FEB. 1957

SCALE AS SHOWN

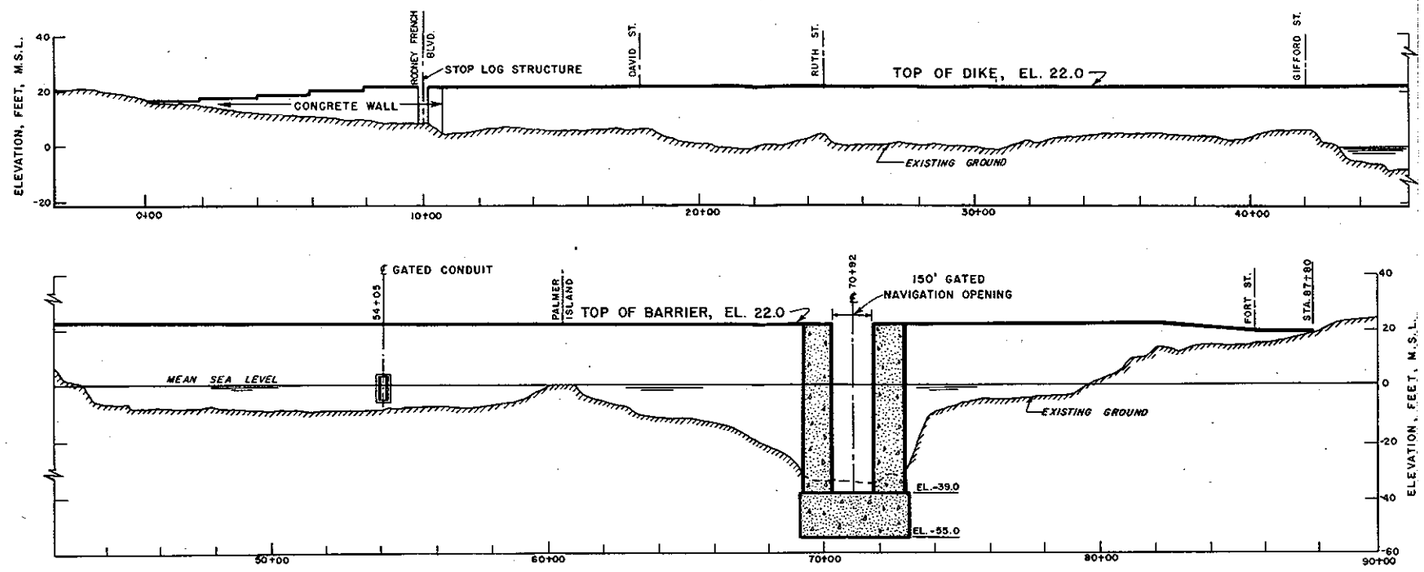
DRAWING NUMBER NBFA-1-1002

SHEET 2 OF 6

PLATE E-2

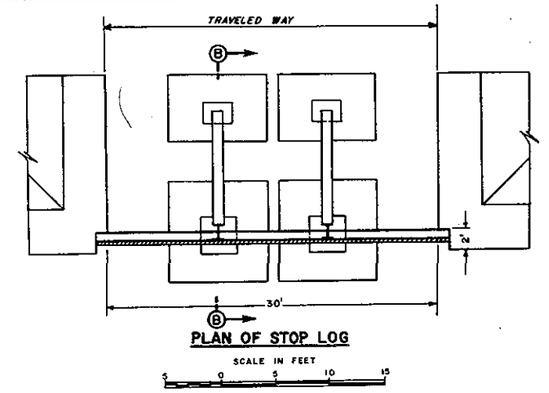
CORPS OF ENGINEERS

U. S. ARMY



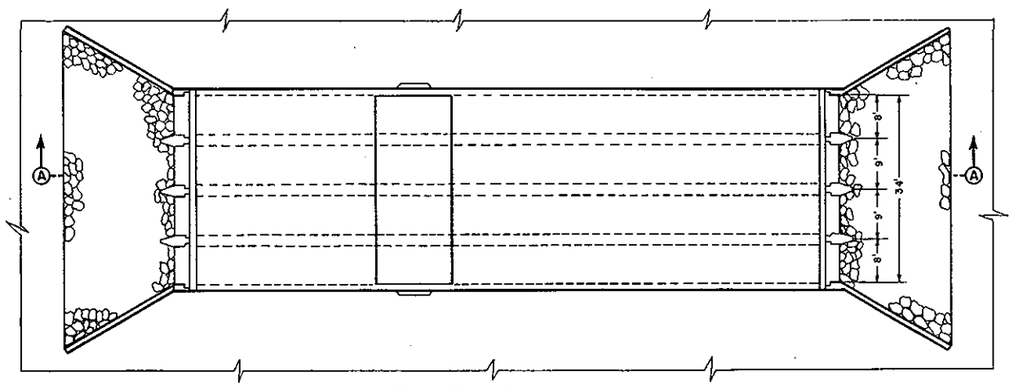
PROFILE ALONG ℄ OF NEW BEDFORD HARBOR BARRIER

SCALE AS SHOWN



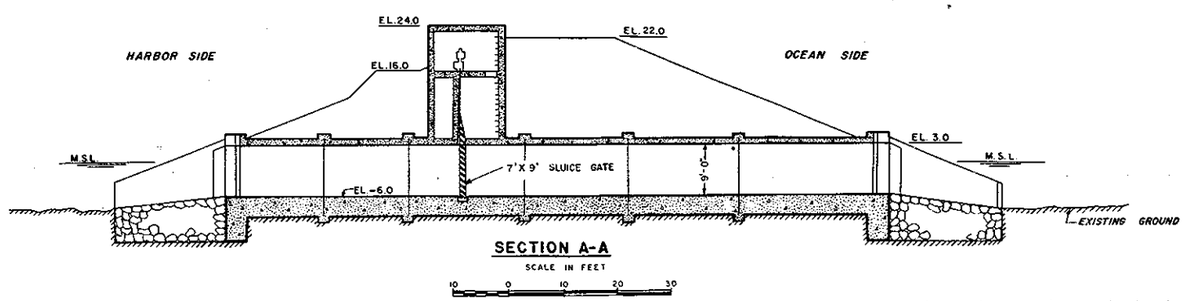
PLAN OF STOP LOG

SCALE IN FEET



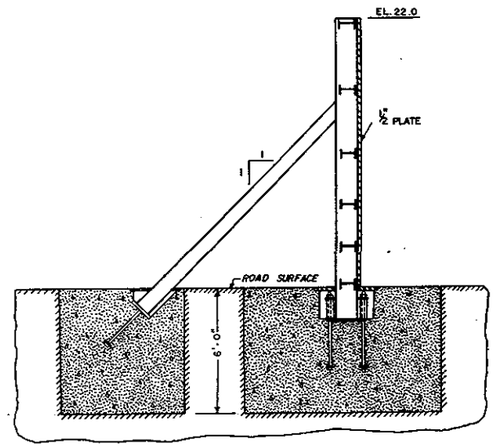
PLAN OF GATED CONDUIT

SCALE IN FEET



SECTION A-A

SCALE IN FEET



SECTION B-B

SCALE IN FEET

NOTE

Elevations are in feet and are referred to Mean Sea Level Datum.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR BY	TR BY	CK BY
J.L.	H.R.	P.A.O.

PROJECT ENGINEER

CHIEF, H.D. HURRICANE UNIT

SUBMITTED BY

CHIEF, ENGINEERING DIV.

APPROVED

CHIEF ENGINEERING DIV.

APPROVED

LT. COL. CE, ASST TO DIVISION ENGINEER

DATE FEB. 1957

HURRICANE SURVEY

NEW BEDFORD-FAIRHAVEN, MASS.

HARBOR BARRIER AND DIKE

PROFILE AND DETAILS

TO ACCOMPANY REPORT DATED 8 FEB. 1957

SCALE: AS SHOWN

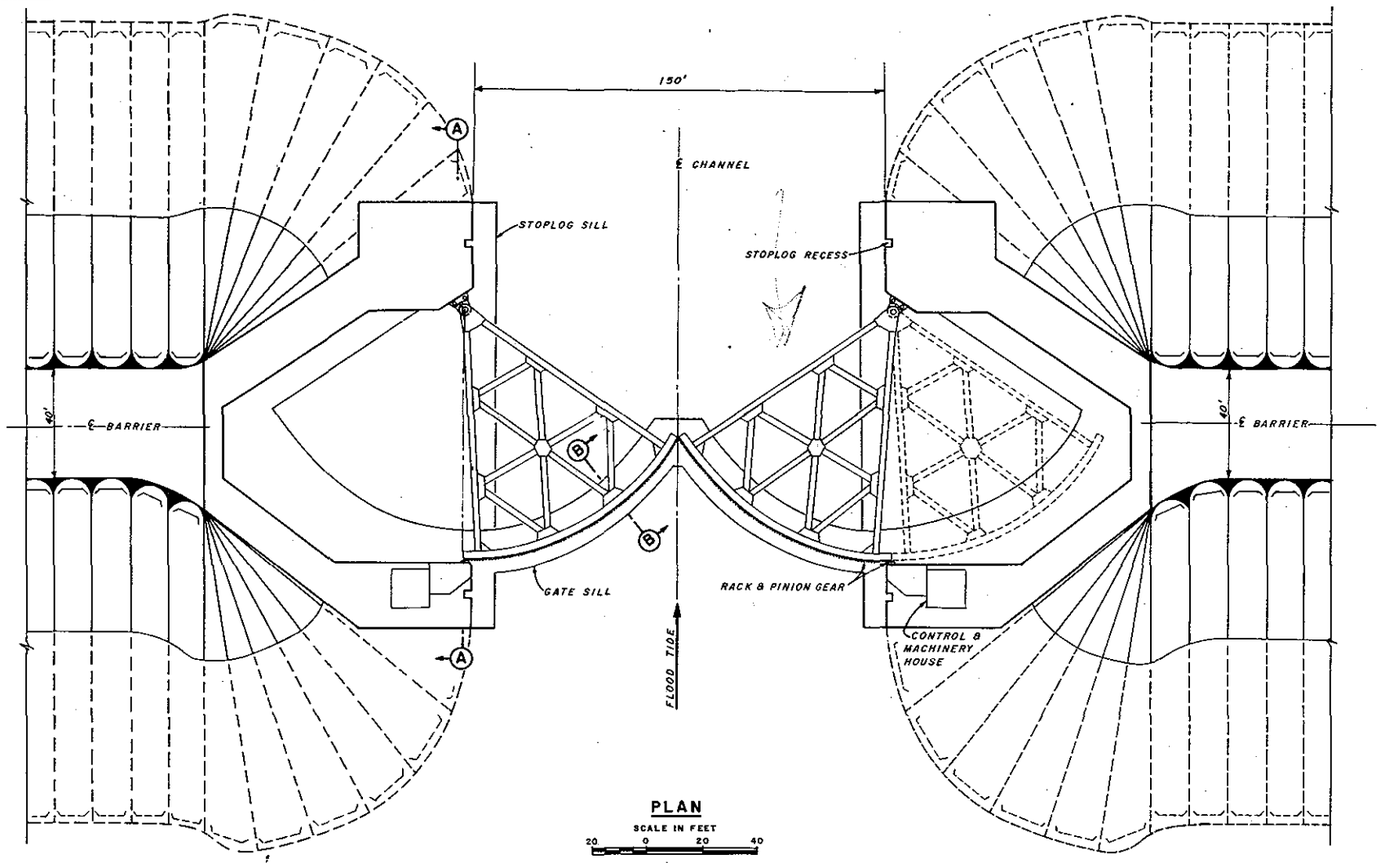
DRAWING NUMBER NBFA-1-1003

SHEET 3 OF 6

PLATE E-3

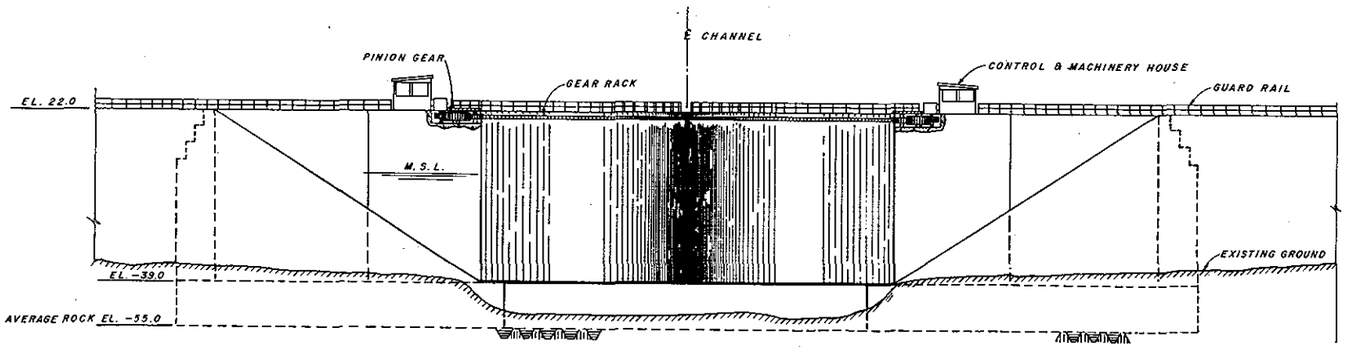
CORPS OF ENGINEERS

U. S. ARMY



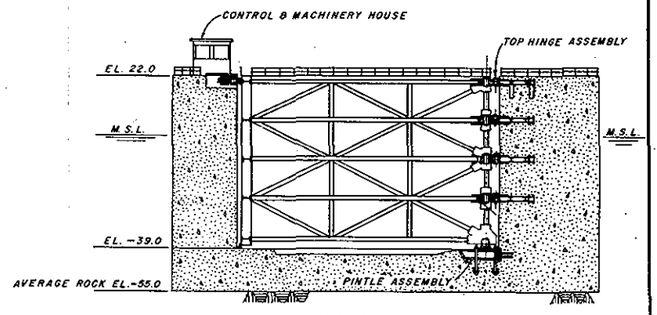
PLAN

SCALE IN FEET 20 0 20 40



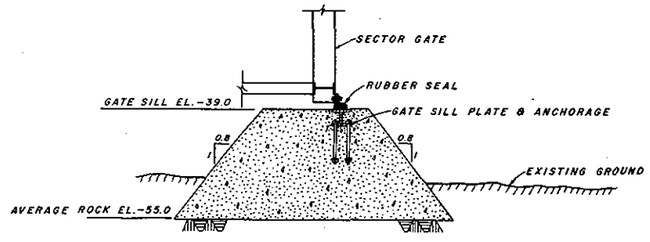
ELEVATION

SCALE IN FEET 20 0 20 40



SECTION A-A

SCALE IN FEET 20 0 20 40



SECTION B-B

SCALE IN FEET 8 0 8 16

NOTE:

Elevations are in feet and are referred to Mean Sea Level Datum

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS.

DR BY	TR BY	CK BY
J.L.	J.L.	F.E.A.O.

PROJECT ENGINEER

CHIEF H.D. HURRICANE UNIT

SUBMITTED BY

CHIEF ENGINEERING DIV.

APPROVED

CHIEF ENGINEERING DIV.

APPROVED

LT. COL. C.E. ASST TO DIVISION ENGINEER

HURRICANE SURVEY

NEW BEDFORD-FAIRHAVEN, MASS.

HARBOR BARRIER AND DIKE

SECTOR GATE

DATE FEB. 1957

SCALE AS SHOWN

TO ACCOMPANY REPORT DATED 8 FEB. 1957

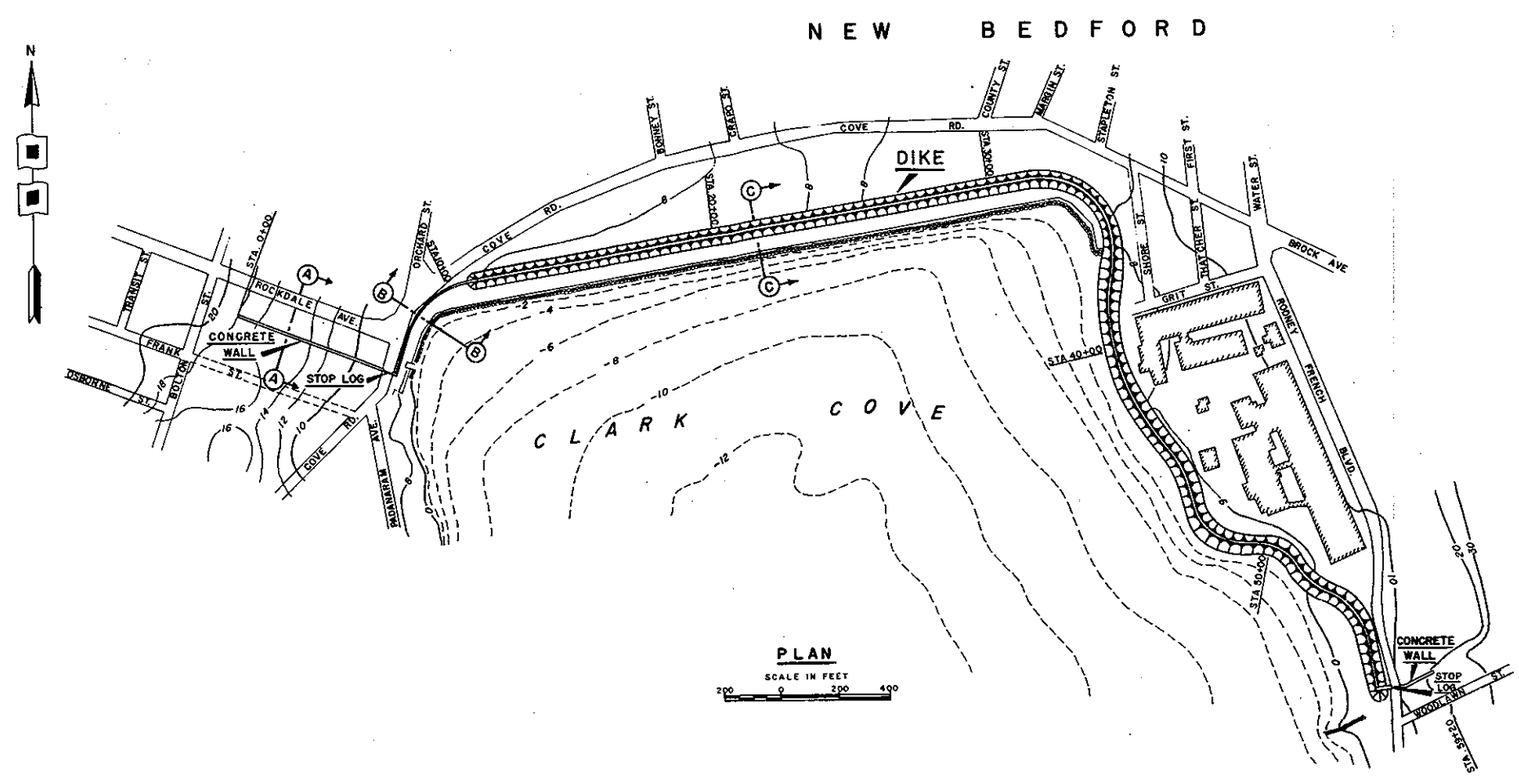
DRAWING NUMBER NBFA-1-1004

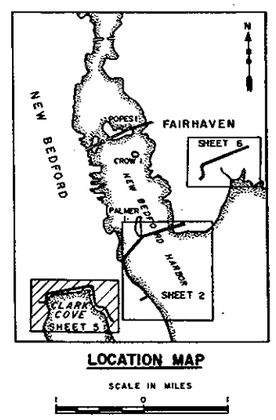
SHEET 4 OF 5

PLATE E-4

CORPS OF ENGINEERS

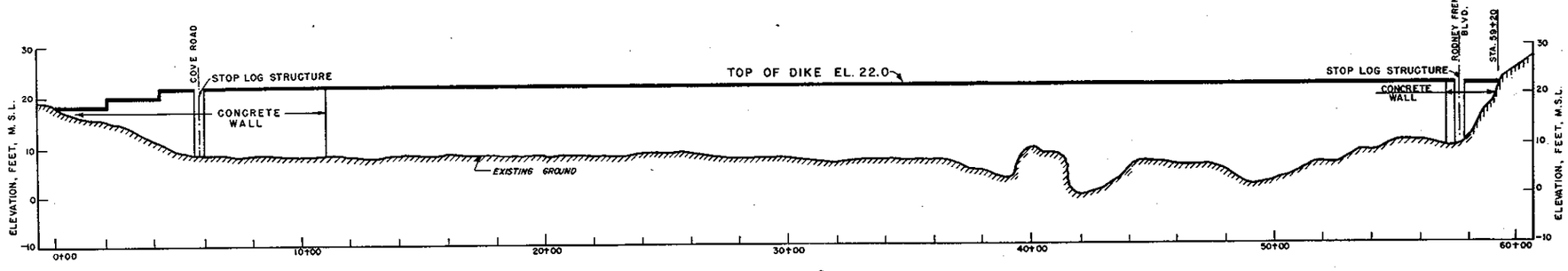
U. S. ARMY





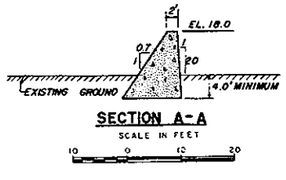
LOCATION MAP

SCALE IN MILES



PROFILE ALONG ℄ DIKE

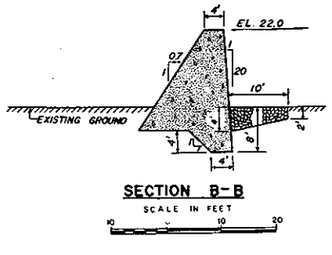
SCALE AS SHOWN



SECTION A-A

SCALE IN FEET

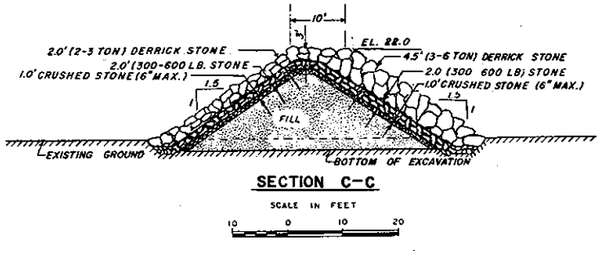
10 0 10 20



SECTION B-B

SCALE IN FEET

10 0 10 20



SECTION C-C

SCALE IN FEET

10 0 10 20

NOTE:

Elevations are in feet and are referred to Mean Sea Level Datum

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR. BY H.H.G.	TR. BY H.R.	CK. BY W.J.K.
PROJECT ENGINEER		
CHIEF, E & H HURRICANE UNIT		
SUBMITTED BY		
APPROVED BY CHIEF ENGINEERING DIV.	APPROVED BY ACTING ASST TO DIVISION ENGINEER	DATE FEB. 1957

HURRICANE SURVEY

NEW BEDFORD-FAIRHAVEN, MASS.

CLARK COVE DIKE

PLAN, PROFILE AND SECTIONS

TO ACCOMPANY REPORT DATED 8 FEB. 1957

SCALE AS SHOWN

DRAWING NUMBER NBFA-1-1005

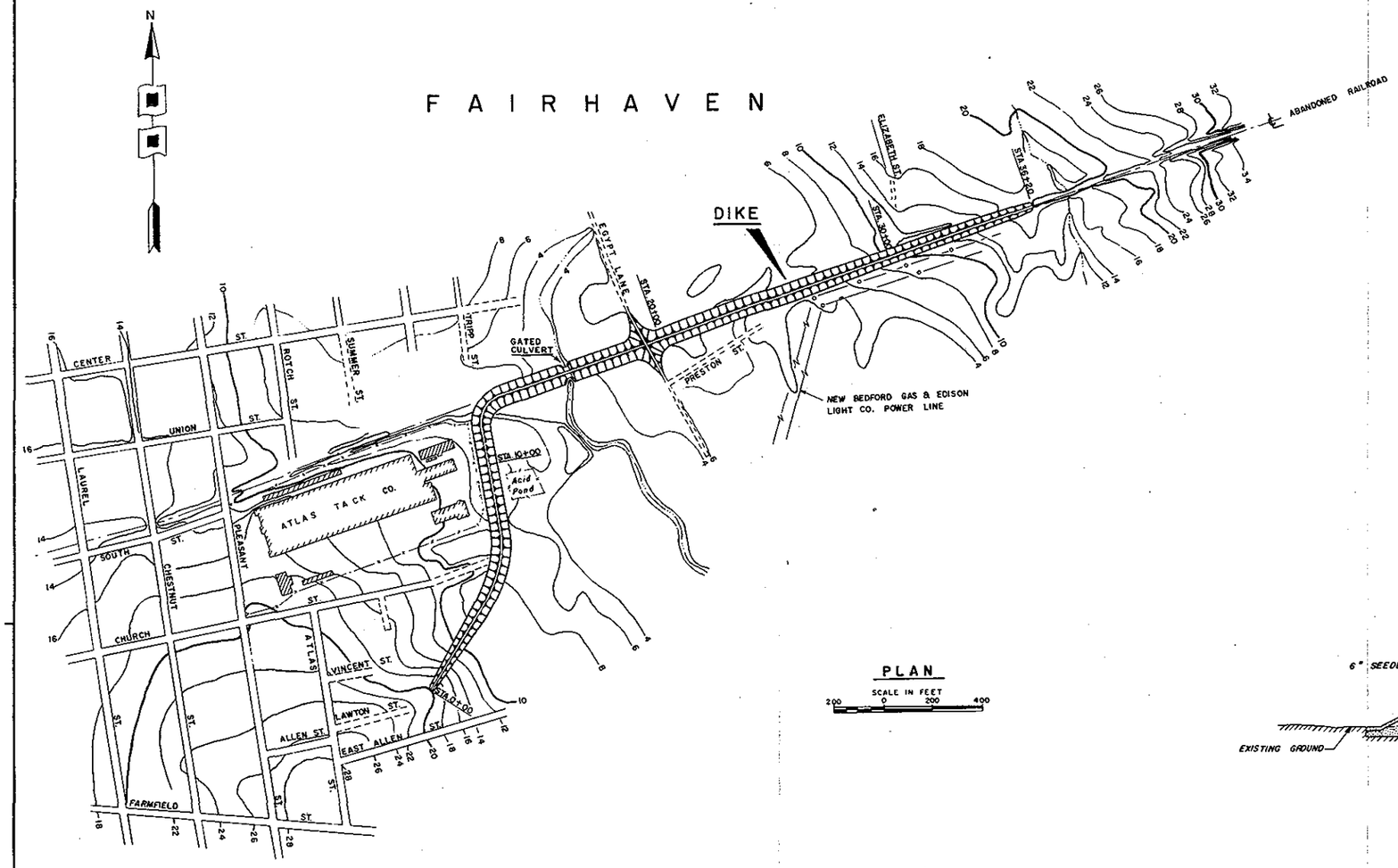
SHEET 5 OF 6

PLATE E-5

CORPS OF ENGINEERS

U. S. ARMY

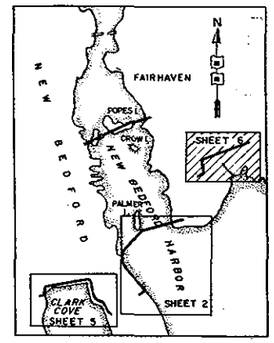
FAIRHAVEN



PLAN

SCALE IN FEET

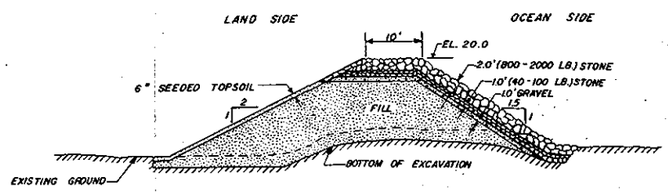
200 0 200 400



LOCATION MAP

SCALE IN MILES

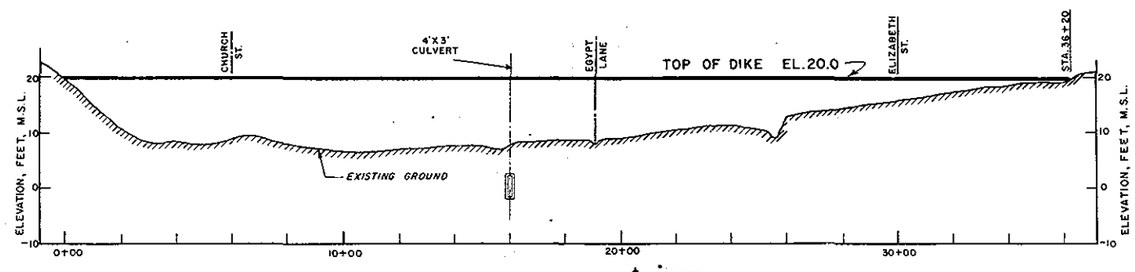
1 0 1



TYPICAL SECTION OF DIKE

SCALE IN FEET

10 0 10 20



PROFILE ALONG ℄ DIKE

SCALE AS SHOWN

NOTE:

Elevations are in feet and are referred to Mean Sea Level Datum.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR BY	TR BY	CK BY
H.R.	M.R.	J.L.I.

PROJECT ENGINEER

CHIEF, N.E. HURRICANE UNIT

SUBMITTED BY

APPROVED

CHIEF, ENGINEERING DIVISION

HURRICANE SURVEY

NEW BEDFORD-FAIRHAVEN, MASS.

FAIRHAVEN DIKE

PLAN, PROFILE AND SECTION

DATE FEB. 1957

APPROVED

LT. COL. C.E. ASST TO DIVISION ENGINEER

TO ACCOMPANY REPORT DATED 8 FEB. 1957

SCALE AS SHOWN

DRAWING NUMBER NBFA-1-1006

SHEET 6 OF 6

PLATE E-6

APPENDIX F

LETTERS OF COMMENT

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE
Region II
42 Broadway
New York 4, N.Y.

24:SE
October 5, 1956

Division Engineer for Civil Works
Corps of Engineers, U. S. Army
New England Division
150 Causeway Street
Boston 14, Massachusetts

Attention: Colonel Miles L. Wachendorf
Assistant Division Engineer

Dear Sir:

Reference is made to your letter of August 23, 1956 relative to the hurricane tidal flooding protection project for the New Bedford-Fairhaven area, Massachusetts. The Massachusetts Department of Public Health has "approved the proposal designated as Plan F, including walls and dikes on land in Clark Cove area of New Bedford, a rock and earth dam across New Bedford Harbor in the vicinity of Palmer Island with a dike and wall extending along Rodney French Boulevard in New Bedford and a dike in Fairhaven.

The Department is of the opinion that the proposal will have little or no effect on the water pollution and vector control programs of the Commonwealth."

This office has no further comment to offer at this time.

For the Regional Engineer.

Sincerely yours,

L M Klashman

Lester M. Klashman
Acting Assistant Regional Engineer
Water Supply & Water Pollution Control

SAMUEL B. KIRKWOOD, M.D.
Commissioner

The Commonwealth of Massachusetts

Department of Public Health

511 State House, Boston 33 September 6, 1956

Corps of Engineers, U. S. Army
Office of the Division Engineer
New England Division
150 Causeway Street
Boston 14, Massachusetts

Re: NEW BEDFORD-FAIRHAVEN
Hurricane Protection
Plan

Gentlemen:

The Department of Public Health has considered your communication of August 23, 1956, relative to Plan "F", Hurricane Protection, New Bedford-Fairhaven, Massachusetts.

The present proposal is to construct a rock and earth dam across New Bedford Harbor in the vicinity of Palmer Island with a top elevation approximately 22 feet above mean sea level and with a 150-foot gated opening and gated conduits, which provide a water opening of approximately 240 square feet. This is a considerable departure from the proposal discussed in this office of a type of a structure which would permit freer flows of water in and out of the harbor area.

The Department understands that the presently proposed structure will affect no appreciable change in the tidal regimen of the river and harbor north of the dam. The Department, therefore, has no objection to the current proposal which in its opinion will not result in adverse sanitary conditions in the river or harbor.

Respectfully,

C. I. Sterling Jr.

Clarence I. Stebling, Jr.
Deputy Commissioner
Environmental Sanitation

REGION 5

NEW ENGLAND STATES
NEW YORK
PENNSYLVANIA
NEW JERSEY
DELAWARE
WEST VIRGINIA

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

OFFICE OF REGIONAL DIRECTOR
BLAKE BUILDING
BOSTON 11, MASSACHUSETTS

IN REPLY REFER TO:

October 1, 1956

The Division Engineer
New England Division
U. S. Corps of Engineers
150 Causeway Street
Boston, Massachusetts

Dear Sir:

Reference is made to your letter of August 23, 1956 and to our reply dated September 6, 1956.

This office has contacted Mr. Francis Sargent, Director of the Massachusetts Division of Marine Fisheries concerning the possible impact on fish resources of the hurricane damage control plan for New Bedford Harbor. There is general concurrence that the plan would not have an adverse effect on fishery resources of the area.

Very truly yours,

E. W. Bailey
Acting Regional Director